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A PLEA AND A PLAN

FOR THE

ERADICATION *of* MALARIA

THROUGHOUT THE

WESTERN HEMISPHERE

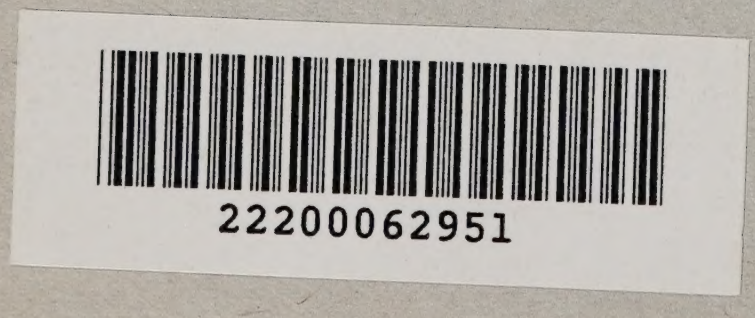
By

FREDERICK L. HOFFMAN, LL.D.

STATISTICIAN
THE PRUDENTIAL INSURANCE COMPANY
OF AMERICA

AN ADDRESS

Read in abstract before The Southern Medical Association
Tenth Annual Meeting
Atlanta, Georgia, November 14, 1916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A Plea and a Plan For the Eradication of Malaria Throughout The Western Hemisphere

By FREDERICK L. HOFFMAN, LL.D.
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TO

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ON

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IN ACCORDANCE WITH ARTICLE 39

OF THE FINAL ACT OF THE

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CONGRESS

WASHINGTON, 1916

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(*16*) The Sanitary Progress and Vital Statistics of Hawaii; 1916.
(*17*) A Plea and a Plan for the Eradication of Malaria, 1917.
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(*1a*) A Statistical Study of Measles; 1913.
(*2a*) A Statistical Study of Whooping Cough; 1914.
(*3a*) Medical Inspection of Schools—a Factor in Disease-Control; 1915.
(*4a*) Anthropometric Table; Children Aged Six to Forty-eight Months; 1916.
(*5a*) The Mortality from Diseases of the Lungs in American Industry; 1916.

CHARTS

I Mortality from Cancer (21 charts).
II Mortality from Tuberculosis (21 charts).
III Mortality from Measles (5 charts).
IV Mortality from Whooping Cough (4 charts).
V Mortality from Accidents (7 charts).
VI Mortality from Typhoid Fever (1 chart).
VII Mortality from Infantile Paralysis (1 chart).
VIII Mortality from Diphtheria (5 charts).
IX Mortality from Malaria (4 charts).
X Mortality of United States and Germany (3 charts).

A Plea and a Plan for the Eradication of Malaria Throughout the Western Hemisphere

PART I

A PLEA FOR ORGANIZED ACTION

PART II

A PLAN FOR ORGANIZED PREVENTION AND CONTROL

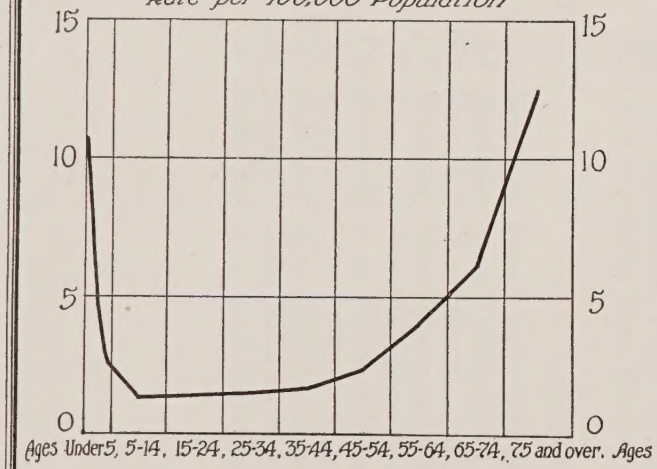
PART III

SOME ESSENTIAL STATISTICAL CONSIDERATIONS

Malaria in the United States, 1910—1914

Malaria Mortality by Age

U. S. Registration Area, 1910-1914
Rate per 100,000 Population



Type of Malaria in Southern States 1913

8,519 Cases

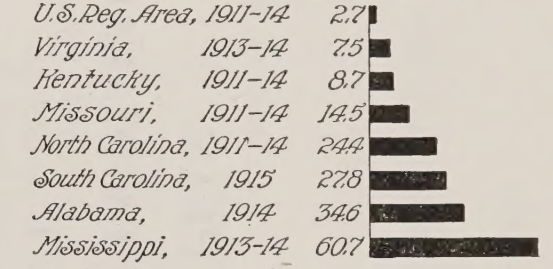
Tertian	65.2 %	Quartan 12.8%	Estivo-Autumnal 22.0%

Case Fatality Rate Mississippi, 1914

Cases ____ 116,788
Deaths ____ 1,030
Percent. ____ 0.88

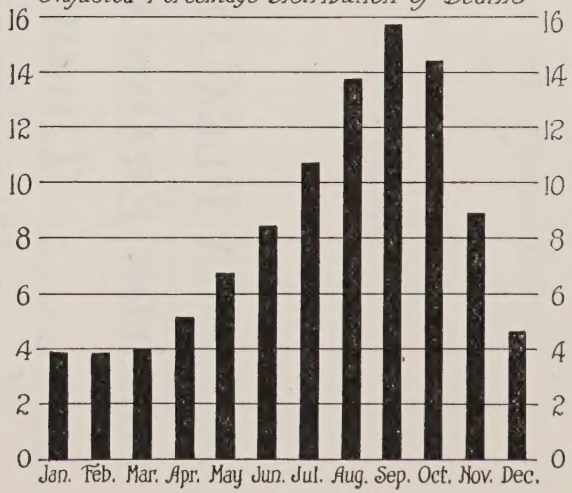
Malaria Mortality in Southern States

Rate per 100,000 Population



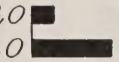
Malaria Mortality by Months

U. S. Registration Area, 1910-1914
Adjusted Percentage Distribution of Deaths



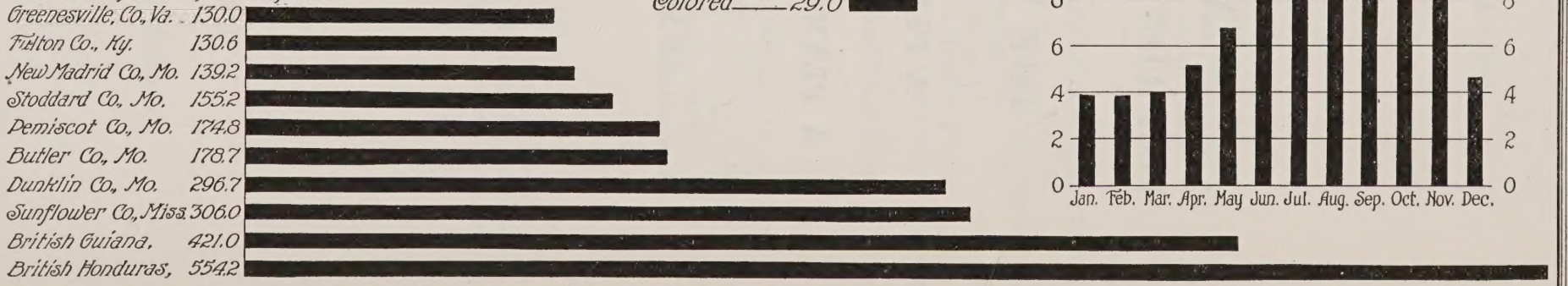
Malaria Mortality by Race

Southern States and Cities, 1910-1914
Rate per 100,000 Population



Malaria Mortality in Areas of Intensive Prevalence 1911—1914

Rate per 100,000 Population



PART I

A PLEA FOR ORGANIZED ACTION

By a resolution adopted by the Second Pan-American Scientific Congress, the United States and all Pan-American countries obligated themselves, singly and collectively, to join in an effort to eradicate malarial diseases from the western hemisphere. However difficult and apparently impossible the task at the present time may seem to those unfamiliar with past achievements in disease prevention, there can be no question of serious doubt in the mind of those familiar with the facts that the aim and end in view will be achieved in due course of time. Whether it will require one generation or ten to secure measurably satisfactory results will depend primarily upon the hearty and efficient cooperation of *all* governmental agencies, federal, state or municipal, and the international cooperation of *all* the principal countries of the western hemisphere, in which the disease is of relatively common occurrence. Among the endemic diseases of our Southern States malaria ranks first in the order of practical importance, and the amount of suffering caused by it and the social and economic losses resulting from it far exceed those of all the other endemic diseases, chiefly pellagra and hookworm, but also amoebic dysentery, leprosy and blackwater fever, leaving out of consideration for the time being whether the last named should not properly be included within a broad definition of malarial diseases in general terms. Hookworm disease unquestionably is of enormous importance, but its eradication is less difficult than the complete elimination of malarial disease, on account of the wider dissemination and the more insidious nature of malaria and the complicated relationship between the mosquito and man. The fevers of the South are a medical subject which has been under extended consideration from the very settlement of the country, and, to a not inconsiderable extent, Southern medical practice and malarial diseases, obviously or obscurely, involve each other.

The literature of malaria is so enormous that it hardly serves a useful purpose to refer even briefly to the earlier dissertations, such as "The History, Diagnosis and Treatment of the Fevers of the United States," by Elisha Bartlett, of which the first edition was printed in 1847, the less generally known "Observations upon the Autumnal Fevers of Savannah," by Dr. W. C. Daniell, Savannah, 1826, and the classical treatise on "The Most Common Diseases of the South," by Thompson McGown, Philadelphia, 1849, in which the congestive fevers and the remittent fevers occupy the most prominent place.

Fenner's "Southern Medical Reports" contain numerous and convincing illustrations of the enormous losses caused to the Southern States by the prevalence of uncontrolled malarial fevers during the period immediately preceding the Civil War; and the medical history of that great conflict* bears mute evidence to the havoc caused by malarial diseases to the armies, North and South, because of the fact that the underlying causes and conditions responsible for disease frequency were completely misunderstood.

Contrasting these earlier inquiries and observations of the foremost medical men of the period with modern works on malarial fevers by Celli, with special reference to Italy, † by Ross, by Craig, by Thayer, by Sternberg, by Henson, by Deaderick, and finally by the group of extraordinary men in charge of the sanitary administration of the construction and maintenance of the Panama Canal, ‡ the contrast is not more striking, nor in a measure more indicative of a promising future, than the earlier misconceptions of the cause of tuberculosis and the revolution in medical and sanitary practice following the immortal discovery of the tubercle-bacillus, by Robert Koch. In 1870, C. F. Oldham, M. D., assistant surgeon of the Indian forces, and a fellow of the Royal Medical and Chirurgical Society, wrote a monograph entitled "What is Malaria, and Why Is It Most Intense in Hot Climates." His attempted explanation left the problem unsolved. Forty years later the Royal Society published the reports of a special malaria committee, in which, in conformity to the exacting methods of modern science, the true factors and elements of the disease were set forth with admirable precision and completeness, and continued the work with a series of eight reports, ending with 1903. Step by step a new science of preventive medicine has been developed, and of the ever-increasing group of preventable diseases, malaria, without question, ranks first as the most obviously eradicable of all.

The earlier speculations concerning the mode of infection have been supplanted by exact scientific researches regarding the true mode of transmission, confirmed by subsequent experience, and few now seriously question the conclusiveness of the results. The mosquito as a transmitting agent is to-day the recognized causative agent, although the mosquito itself is not the cause, as is frequently assumed to be the case. The parasite which develops malaria is transmitted by the mosquito to man, and if the mosquito itself is not infected there is no possibility of malaria causation. The mode of infection is thoroughly understood, and the known facts about the mosquito have increased to the extent that the subject has a literature of its own, and the methods of individual and public malaria prevention are now common knowledge, however little that knowledge may be publically applied.

*"Medical and Surgical History of the War of the Rebellion," Vols. i-iii, Washington, 1888. See, also, article on Malaria, Index Surgeon-General's Library, Vol. x, Washington, 1905.

†See, also, "Atlante di Demografia Medica d'Italia," by Dr. Enrico Raseri, Roma, 1906.

‡Proceedings Canal Zone Medical Association, Vol. i-viii, Ancon, Canal Zone, 1908-1915.

A PLEA FOR ORGANIZED ACTION

As stated by Sir Ronald Ross, the most distinguished authority on malaria, and himself the discoverer of the causative agent, or of the transmission of the disease by mosquitoes, "malarial fever is perhaps the most important of human diseases, and though it is not often directly fatal, its wide prevalence in almost all warm climates produces in the aggregate an enormous amount of sickness and mortality." In times past malaria was not limited, and it is not even to-day limited, to warm climates, as best illustrated in the "Essays on Fevers," by Miner and Tully, published at Middletown, Conn., in 1823, which includes an extended account of a yellow-fever epidemic in that community, however incredible the possibility of such an occurrence may appear at the present time. Remittent fevers in the Central States, in the prairie regions, along the margins of the Great Lakes, in central New York and in New England, during the early years when the country was being settled, caused a heavy mortality, an enormous amount of sickness and a correspondingly considerable economic loss.* By the settlement of the land, by the elimination of pools of standing water, by the drainage of swamps, gradually, though at a truly lamentable cost, the northern section of the United States has become practically free from malarial infection. There is still, however, a measurable remnant of malaria, and the possibilities of a serious outbreak exist in every community where the anopheles mosquitoes prevail to a considerable extent.† The best illustration is the recent epidemic in Greenwich, Conn., a very healthy suburban community near New York, where, because of municipal negligence and private indifference, the evil assumed such proportions as to call for drastic state and even governmental interference.‡ In the great interior valley of California malaria prevails in many localities to such a degree as to prove a serious hindrance in the development of otherwise promising localities,

*See Annual Reports of the Michigan State Board of Health, 1874, 1875, 1879, 1881, 1882. See, also, "A Systematic Treatment on the Principal Diseases of the Interior Valley of North America," Vol. i, by Daniel Drake, M. D., Cincinnati, 1850.

†An exceedingly interesting reference to the occurrence of fevers during the pioneer period of the Central West appears in a report on the medical topography and epidemic diseases of Illinois, contributed to the Transactions of the American Medical Association, Vol. xviii, Philadelphia, 1867, reading, in part: "The testimony borne by the early explorers and settlers of the state of Illinois was anything but flattering to its character for healthfulness and salubrity . . . Fevers due to miasmatic causes were of frightful frequency among the pioneers, and, to no inconsiderable extent, still prevail in the alluvial bottoms of the rivers."

In the same transactions was published a prize essay on the cause of intermittent and remittent fevers, by J. R. Black, M. D., of Newark, Ohio, in which references occur to the frequency of intermittent and remittent fevers in the gold regions of California. The assumed law of intensity and frequency occurrence in periodical fevers is stated to be that: "With a summer mean temperature of sixty degrees, and upwards, the greater the diurnal oscillations of temperature the greater, caeteris paribus, will be the prevalence of autumnal fevers, and with the increase of the mean is the increased susceptibility to fluctuations; the higher the mean the smaller, comparatively, the oscillation requisite to produce the morbid phenomena, and the more intense their character" (p. 457).

‡Of special value in this connection are the following: A Report on the History of Intermittent Fever in the New Haven Region, contributed to the Proceedings of the Connecticut Medical Society, 1872; An Account of Malaria in Connecticut, Including Observations on Malaria in Greenwich, as Early as 1811, in the Fourth Annual Report of the State Board of Health of Connecticut, Hartford, 1882; An Account of Epidemic Intermittent Fevers in Connecticut, in the Fifth Annual Report of the Connecticut State Board of Health, Hartford, 1883; A Special Report of the Health Officer of Greenwich for 1912, in the Thirty-second Report of the Connecticut State Board of Health, Hartford, 1913; Observations on Mosquito Conditions and Mosquito Surveys in Connecticut in 1915, in the Annual Report of the Connecticut Agricultural Experiment Station, New Haven, 1916; an exceedingly interesting communication from the Greenwich Medical Society was published in the New York *Globe*, January 31, 1913.

and real-estate values are correspondingly depressed, because of the natural aversion of people to live in, or to remove to, obviously unhealthful localities.

Sickness is no longer looked upon as inevitable or as an evil to be borne without complaint. Ill-health is now recognized as a most serious hindrance to the highest development of the individual and of the people collectively considered. With an ever-increasing economic pressure the necessity for the elimination of ill-health-producing conditions has become a governmental problem of the first order of importance, and in no special field of preventive medicine have the actual results of governmental interference and control been more satisfactory and conclusive than in the prevention of malaria. Among the most useful summary accounts of what has actually been achieved, attention may be directed to the treatise on "The Health Progress and Administration in the West Indies," by the late Sir Rupert Boyce, which includes some very interesting observations on education as a prophylactic factor in the West Indies, the war against insect pests, the law against stagnant water in some of the West Indian colonies and finally the extension of disease by modern commercial intercourse. More recent, and still more instructive and conclusive, is the work on "Rural Sanitation in the Tropics," by Malcolm Watson, being an account, amplified by personal observations, of what has been achieved in the prevention of malaria in rural sections, chiefly of the Malay Archipelago, the Panama Canal Zone, British Guiana, etc. Of special interest and value in this work are the rules and regulations for estate sanitation, which are perhaps best illustrated by the practical results obtained in the sanitary administration of Hawaii, chiefly with regard to the sugar plantations.* The magnificent hospitals of the United States Rubber Company in the Dutch East Indies have no parallel in any rural section of the southern United States. Rural sanitation and malaria prevention in the South are practically equivalent terms, and the one, broadly speaking, can not be achieved without the other. Malaria prevention, to be permanently successful, however, requires the most complete coordination of governmental, corporate and private functions and efforts, to the same extent to which this has been the case in Panama, where practically the whole population has been brought under almost perfect sanitary control.

Thus far on the mainland of the United States we have not developed a well-considered *national plan* for malaria eradication, nor have we perfected even the underlying organization for an effective agitation of the question as a matter of general public policy. Our schools of tropical medicine are poorly financed, and their work is far from having attained to the practical importance of the corresponding efforts of the Liverpool School of Tropical Medicine, which has sent out one malaria expedition after another, as a result of which there has gradually been brought together a series of monographic studies of actual achievements

*"The Sanitary Progress and Vital Statistics of Hawaii," Prudential Press, Newark, N. J., 1916.

that may well challenge the admiration of mankind. Among others, the school has reported on the malaria expedition to Sierra Leone, by Sir Ronald Ross, the malaria expedition to Nigeria, by Annett, the progress of the campaign against mosquitoes in Sierra Leone, by Taylor, the prevalence of malaria in Ismailia and Suez, the malaria expedition to Gambia, the sanitary conditions obtaining in Para, and finally a suggestive outline of the practical study of malaria and other blood-parasite diseases. With vast commercial interests to the south of us in countries seriously hindered in their physical, social and economic progress on account of the still extensive prevalence of malaria, we have practically made no efforts in the direction of extensive scientific research deserving of serious consideration, excepting, of course, the monumental work carried on and completed under the direction of Major-General W. C. Gorgas in Panama.

Regardless of our greater wealth and commercial necessity we have made no thoroughly scientific malaria research comparable to the results reported upon in memoirs by officers of the medical and sanitary departments of the Government of India, including monographs on malaria in India, by Capt. S. P. James, malaria in the Punjab, by Maj. S. R. Christophers, reports on the antimalarial operations at Mian Mir, by Capt. S. P. James, and finally reports by the same distinguished authority on kala-azar, malaria and malarial cachexia. It is true, of course, that malaria in India is absolutely of the very first order of practical importance, and that any measures and means of the Government of India in the direction of malaria prevention are certain to prove productive of enormous value to the people of India and the Europeans who, as civilians or for military purposes, temporarily or permanently reside there. But the same conclusion applies at least to the southern portion of the United States. According to Sir Ronald Ross, it has been estimated that the mean annual death rate of India from malaria is about 5 per 1,000, and that the annual actual mortality is about 1,130,000. Fevers in India, as officially reported, unfortunately include diseases other than malaria, and the true incidence of the disease is, therefore, not at present ascertainable, but there is the most conclusive evidence that the seriousness of the problem has been intelligently recognized by the Government and the people of India, as illustrated in the series of transactions of the Committee for the Study of Malaria in India, edited by McKendrick and Christophers, which include some exceedingly valuable notes and observations on the seasonable prevalence of anophelines, with special reference to the potentialities of a single breeding-place, and the mathematics and epidemiology of malaria, in amplification of the interesting chapter on the measurement, mortality and cost of malaria in the treatise by Sir Ronald Ross,* which involves considerations also applicable to other problems of preventable diseases.

*"The Prevention of Malaria," by Ronald Ross, New York, 1910. Attention may also be directed here to the monumental treatise on malaria by Dr. Vittorio Ascoli, published under the title "La Malaria," Torino, Italy, 1915.

Such scientific contributions as have been made to the subject of paludism, through the transactions of the Committee for the Study of Malaria in India, emphasize precisely the lesser degree of scientific progress which, in this direction, has been made in the United States regardless of the truly enormous social and economic interests involved in malaria prevention, at least in the Southern States. We have much to learn in this respect, and the results of scientific research in malaria and related problems for the western hemisphere fall far short of the corresponding attainments in the eastern hemisphere, as perhaps best indicated by the remarkable results achieved by the Institute for Medical Research of the Federated Malay States, which in 1902 published a monograph on "The Malarial Fevers of British Malaya," by Hamilton Wright, subsequently enlarged upon by the recently issued treatise on "Rural Sanitation in the Tropics," by Watson, previously referred to, which has special reference to the antimalarial work in Klang, Port Swettenham, and elsewhere in the Straits Settlements,* all more or less in conformity to the control of malaria in Panama. The first and fundamental principle of such an effort is a thoroughly aroused public understanding of the importance and practical possibilities of malaria eradication. Such conspicuous illustrations as the proceedings of the Imperial Malaria Conference, held at Simla, India, 1909, the proceedings of the Third General Malaria Committee, held at Madras, India, 1912, the report on an investigation into the causes of malaria in Bombay and the measures necessary for its control, by Bentley, published in Bombay, 1911, and the two equally interesting and important reports on malaria in Bengal, by Maj. A. B. Fry, published in Calcutta, 1912 and 1914, are sufficient for the present purpose of emphasizing the measures and means which have been adopted in other countries than ours, even though the question here, or at least in the Southern States, is not less serious, when all the elements of the problem are taken into account, than in the tropical portions of the British Empire. Regarding no other problem in preventive medicine is the evidence so absolutely convincing. Even tuberculosis can not show anywhere near the remarkable results of actual reduction and gradual elimination which have been the case with malaria whenever thoroughgoing methods and means for complete eradication have been adopted. The statistical evidence in support of this contention is so overwhelming that it may safely be

*In the Straits Settlements, according to the annual report of the Medical Department for 1915, by Dr. W. Gilmore Ellis, the number of cases of malarial fever decreased from 9,474 in 1912 to 5,590 in 1915. The number of deaths from malaria during the same period decreased from 660 to 311. The data are limited to the cases and deaths in the hospitals of the colony. In the Federated Malay States, according to the annual report of Dr. Chas. Lane Sansom, the mortality from malaria decreased from 17,870 in 1912 to 15,208 in 1915. The report contains an interesting account of antimalarial measures in the different provinces and a report of the Malaria Advisory Board under the supervision of an executive engineer. Appended to the report is a chart showing the true malaria death rate for Kuala Lumpur Town for the period 1907-1915. During the first year the malaria death rate was 9.7 per 1,000, which subsequently to 1911 was gradually reduced to 5.8 during 1912, to 4.2 during 1913, to 3.9 during 1914 and to only 3.7 during 1915. This reduction, achieved through antimalarial measures, was obtained at an aggregate cost of $185,000, for the entire period, largely expended on antimalaria drainage work.

asserted that it is primarily a question of general intelligence coordinated to a high conception of public duty, without which the desired results are not obtainable.

In Jamaica a malaria commission was appointed; it served for a few years, rendered some admirable reports, achieved some far-reaching practical results, but was permitted to terminate because of governmental indifference and neglect.* The relatively small amount of money involved in antimalarial measures in the island of Jamaica could have been saved to advantage from almost any other item of public revenue, with the practical certainty that no other expenditure would prove productive of equally far-reaching social and economic results to the population concerned. This most beautiful island of the West Indies is a hundred years behind in the achievement of its most obvious commercial and social possibilities, largely because of the extensive prevalence of malaria, the impaired physique of the natives, the impossibility of profitable cultivation of large infected areas, and the complications resulting from malaria in the increased seriousness of many other diseases. But in this respect many sections of our Southern States have not done much better, and as yet not a single Southern state has gone so far as to appoint a malaria commission or official state committee for the purpose of making even a preliminary state survey for the ascertainment of all the essential facts and conditions which require to be known.

Over twenty years ago William Sydney Thayer and John Hewetson published their monumental work on "The Malarial Fevers of Baltimore." That work itself constitutes one of the most useful and instructive sources of information regarding the malaria problem. The report was subsequently amplified by Dr. Thayer in a series of lectures on malarial fevers (New York, 1897), including a concise outline of the fundamental principles of malaria pathology, diagnosis, prognosis and treatment. Some years earlier the late Dr. George M. Sternberg published his work on "Malaria and Malarial Diseases," which, in a more comprehensive manner, presented in broad outlines the conditions governing the development and dissemination of malaria, with observations on the speculations and researches relating to the nature of malaria and the general effects of malaria, all of which now make curious and interesting reading, since it was not until 1898 that the true cause of the disease was discovered by the ascertainment of the malarial parasite in the mosquito and the transmission of the disease from mosquitoes to man. From Sternberg to Thayer, and from Thayer to Craig and Deaderick, we have not been wanting in qualified medical research fully on a par with the work of the most distinguished medical authorities of other countries. Where we have failed, and conspicuously

*Annual Reports of the Malaria Commission of Jamaica, December 31, 1910, and for the year ending March 31, 1912, Kingston, Jamaica, 1911-1912.

See, also, the Annual Report of the Superintendent of Health of Jamaica for the year ending March 31, 1915 Kingston, Jamaica, 1916.

so, is in governmental recognition of the administrative aspects of malaria prevention and control and the absolute hopelessness of any measurable progress in the direction of eradication without more or less drastic governmental interference. Within recent years some very valuable local surveys have been made by the United States Public Health Service,* and many scientific papers and reports have been contributed on important technical aspects of malaria distribution, prevention and control, but the efforts of the service in this direction have fallen short of the required permanent results, in view of the want of the necessary coordination of municipal, state and federal efforts, which, for their success, require exact conformity to the admirable administrative principles developed under the direction of Major-General W. C. Gorgas and others in Panama. The principles of mosquito control in the Panama Canal Zone and the actual achievements in the local eradication of malaria and yellow fever in Cuba and Panama have been set forth in an exceptionally lucid and convincing manner by Joseph A. LePrince, formerly chief sanitary inspector of the Isthmian Canal Commission, and Dr. A. J. Orenstein, assistant chief sanitary inspector of the Isthmian Canal Commission, in a work issued during 1916.† This is by far one of the most notable contributions to the practical study of the problem of malaria eradication, and every important factor of the problem receives adequate consideration and is sustained by the gratifying results of actual experience. The essentials of an effective antimalarial campaign at reasonable cost, largely on the principle of intelligent coordination of governmental and other efforts and activities, more or less in conformity to the methods found practical in the Panama Canal Zone, are briefly set forth, as follows:

1. Meteorological and topographical conditions: these are, without question, of the first order of importance. No definite conclusions can be arrived at, however, without a preliminary analysis of the elementary meteorological facts concerning a given community and the precise ascertainment of the essential topographic features, by means of topographic.

*Among the more important of the recent publications of the United States Public Health Service on malaria, malaria eradication, etc., are the following: No. 105, Antimalarial Measures for Farmhouses and Plantations, by H. R. Carter, 1912, No. 108, Malarial Fevers: Prevalence and Geographic Distribution in Alabama, by R. H. von Ezdorf, 1913, No. 159, Malarial Index Work Methods Used in Obtaining Blood, Making Blood Smears and Staining, by R. H. von Ezdorf, 1914, No. 160, Malarial Fevers: Prevalence and Geographic Distribution in Arkansas, by R. H. von Ezdorf, 1914, No. 172, Malarial Fevers: Prevalence and Geographic Distribution in South Carolina, Georgia, and Florida, by R. H. von Ezdorf, 1914, No. 175, Quinine Prophylaxis for Malaria, by H. R. Carter, 1914, No. 186, Malarial Fevers: Prevalence and Geographic Distribution in Alabama, 1913, by R. H. von Ezdorf, 1914, No. 193, Malarial Fevers: Prevalence and Geographic Distribution in Mississippi, 1913, by R. H. von Ezdorf, 1914, No. 217, Mosquitoes and Malaria: Report on a Short Trip in Eastern North Carolina, by Chas. Wardell Stiles, 1914, No. 244, Impounded Water: Some General Considerations of Its Effect on the Prevalence of Malaria, by H. R. Carter, 1915, No. 257, Impounded Waters: A Study of Such Waters on the Coosa River in Shelby, Chilton, Talladega and Coosa Counties, Alabama, to Determine the Extent to Which They Affect the Production of Anophelines, and of the Particular Conditions Which Increase or Decrease Their Propagation, by J. A. LePrince, 1915, No. 258, Malaria Control: Drainage as an Antimalarial Measure, by J. A. LePrince, 1915, No. 272, Anopheline Surveys: Methods of Conduct and Relation to Antimalarial Work, by R. H. von Ezdorf, 1915, No. 277, Malaria in the United States: Its Prevalence and Geographic Distribution, by R. H. von Ezdorf, 1915, No. 260, Control of Malaria: Oiling as an Antimosquito Measure, by J. A. LePrince, 1915.

†"Mosquito Control in Panama," by J. A. LePrince and A. J. Orenstein, with an introduction by L. O. Howard, New York, 1916.

geological and soil surveys. As yet only a relatively small portion of the Southern States has been completely surveyed in conformity to modern topographic methods. For economic reasons it has seemed best to the United States Geological Survey to give prior consideration to western and northern states. Every community is individually interested, however, in the exact ascertainment of local topographic features, which have a direct and permanent relation to the mosquito and the malaria problems. Of somewhat lesser importance is the ascertainment of surface geologic features, which in many sections of the South have been mapped by state surveys with admirable accuracy and completeness.* This conclusion applies particularly to the surveys which have been made of the coastal plains of Maryland, Virginia, North Carolina and Georgia. Particularly good work in this direction has also been done by the State Geological Survey of Florida. Soil surveys are of great practical importance, and it is most fortunate that comparatively rapid progress has been made in this direction by the Bureau of Soils of the United States Department of Agriculture, and a large portion of the Southern States has been mapped with reasonable completeness and attention to details. These maps are of special value in that they indicate the stream margins, swamps, ponds, overflowed land, etc., which, broadly speaking, are the underlying topographic conditions chiefly responsible for the local frequency and relative intensity of malarial diseases.

No thoroughgoing analysis has been made of meteorological features, which in all probability, however, will be found to be of secondary importance. While there is probably a fairly constant correlation between rainfall and malaria, much depends upon topographic features, temperature, humidity and wind direction, aside from proximity to the sea. A very interesting investigation of the meteorology of malaria, reported upon in considerable detail by Matthew D. O'Connell in the *Journal of Tropical Medicine*, emphasizes the urgency of an analysis in complete detail of the temperature of the air, the drying power of the air and the hourly velocity of the wind, and their possible correlation to malaria, the object being to ascertain the atmospheric conditions which raise the body temperature to a condition equivalent to thermic fever.† The view held by Dr. O'Connell is that malaria is *not* caused by mosquito transmission or malaria parasites, and he refers to the relative absence of malarial fevers from England at the present day as not to be explained by the paucity of malarial parasites, since they are imported in abundance in the blood of soldiers, sailors and others who are invalided home for

*A strong appeal for endorsement and support in behalf of an effort to bring about the early completion of the topographic map of the United States has been sent out by a Committee to Expedite the Completion of the Topographic Map of the United States, of which Prof. William F. Davis, geologist, is the chairman. This is deserving of the most hearty support on the part of all who are interested in the scientific and economic solution of the problem of malaria eradication.

†An instructive contribution on "Some Habits of Malaria not Controlled by the Mosquito" was published in 1901 by Dr. Charles Hicks, of Dublin, Ga., illustrated by a map of Laurens County, which suggests the scientific value of thoroughly specialized local malaria studies. A soil survey of Laurens County was published by the Bureau of Soils in 1916.

this disease from countries where they had contracted it.* He therefore holds that "The absence of malarial fevers from England at the present time can hardly be due to any scarcity of anopheles," and he concludes that "it seems certain that malarial fevers have disappeared from England without the employment of any antimalarial measures except the drainage of marsh and fen land, and since the drainage of marsh and fen land has not exterminated anopheles in England, it is difficult to understand what caused the disappearance if they are spread by the mosquito."† It is, therefore, quite clear that qualified opinion is not yet in entire agreement even regarding the causative factor in malarial disease, and the researches of Dr. O'Connell are deserving of consideration as suggestive of unrealized possibilities in the scientific study of meteorology in relation to this disease. As a practical question, however, it may safely be said that thoroughgoing antimalarial measures, involving the destruction of breeding-places of anopheles and the reduction of the same to relatively unimportant proportions, have invariably been followed by the eradication or substantial reduction of the disease.‡

2. The species of anopheles and other mosquitoes in the area affected by malarial disease: It is not merely sufficient to ascertain the relative frequency and species of anopheles, but it is advisable to include in a thoroughgoing scientific survey the correct ascertainment of all the local species of mosquitoes, whether known to be malaria-carrying or not. The elaborate investigations of the mosquitoes of North and Central America and the West Indies by Howard, Dyar and Knab constitute a truly monumental contribution to the cause of ultimate malaria eradication, which rests fundamentally upon the prior ascertainment of the species and relative frequency of mosquitoes of the malaria-carrying variety. These researches have been made available through the Carnegie Institution of Washington, in continuation of Dr. Howard's earlier investigations as chief entomologist of the United States Department of Agriculture. Mention requires to be made in this connection of the exceedingly useful work in the same field by John B. Smith, State Entomologist of New Jersey, published as a report of the New Jersey State Agricultural Experiment Station, in 1904.§ The report includes observations in minute detail on the anatomy of mosquitoes, the habits of mosquitoes, the processes of development and hibernation and finally the relation of mosquitoes to disease, and practical considerations of checks and remedies, including the natural enemies of mosquitoes, remedial measures

*The subject of marsh fevers as distinct from ague in epidemic form is described by Creighton in his "History of Epidemics in Great Britain," who also deals extensively with the whole subject of ague and its prevalence in early times throughout England and Ireland.

†The original articles by Dr. O'Connell were published in the *Journal of Tropical Medicine*, London, 1912 (Feb. 15, June 15, Aug. 15 and Nov. 15), 1913 (June 2, Sept. 1 and Dec. 1), 1914 (Nov. 2), 1915 (May 1 and Aug. 2) and 1916 (Mar. 15 and Dec. 15).

‡For a concise but comprehensive account of the practical results of antimalarial measures, see the articles by special contributors for different countries of the world included in the treatise by Sir Ronald Ross on the "Prevention of Malaria," New York, 1910.

§Report of the New Jersey State Agricultural Experiment Station upon the Mosquitoes Occurring within the State, Their Habits, Life History, etc., by John B. Smith, Sc. D., Trenton, 1904.

in general and destructive measures, as well as observations on mosquito campaigns. In the same field of practical economic entomology a brief reference is called for to a bulletin on mosquitoes, by the University of the State of New York, as a contribution to the New York State Museum, by E. P. Felt, state entomologist, including observations on the distribution and abundance of mosquitoes, the migration by flight, the methods of collecting and breeding, the haunts and breeding-places, natural enemies and finally methods of control.* A strictly scientific mosquito survey is, therefore, of the first importance in all local anti-malarial measures, and without such a survey such measures are practically certain to fail. This, of course, requires the aid of voluntary scientific assistants in the ascertainment of the prevailing species of mosquitoes, whether malaria-carrying or not, in areas subject to malaria, since it is a foregone conclusion that intensive investigations of this kind can not be carried to a final conclusion by paid investigators alone. The most practical suggestions with reference to the collection of mosquitoes have been published by the Museum of Natural History, of the City of New York, but unfortunately the publication is out of print.

3. Anopheles propagation areas: The ascertainment of anopheles propagation areas is, of course, another essential step in any and every mosquito-eradication campaign. The breeding-places being known, the methods of eradication become less difficult. It is absolutely necessary, as shown in the experience which has been had on the Isthmus of Panama, that *all* the breeding-places must be ascertained in practically minute detail. This means, however, that the area to be made free from mosquitoes may be of rather limited extent, since any and all efforts at general eradication over large areas are certain to fall materially short of the expected results. It is an error to assume that the Panama Canal Zone has been made free from anopheles mosquitoes. The conclusion applies only to the inhabited area and a relatively small surrounding section. In the aggregate, perhaps, less than ten per cent. of the entire Canal Zone has been brought within thoroughgoing methods of mosquito control and the equivalent malaria eradication. Obviously the ascertainment of anopheles propagation areas is most difficult without the aid of accurate topographic and soil surveys. In any event, such efforts are materially assisted by maps showing, in complete detail, the salient topographic and soil features of the region under consideration. The elimination of anopheles propagation areas is frequently a most difficult and often an expensive matter, but as a general rule a material reduction in malaria-carrying mosquitoes by means of the elimination of propagation areas can be secured at moderate expense. The essentials of such elimination are set forth by LePrince and Orenstein, as follows:

(*a*) Attacks on propagation areas by filling.

*Bulletin No. 79 of the New York State Museum, Albany, 1904, "Mosquitoes or Culicidae of New York State," by Ephraim Porter Felt.

(*b*) Attacks on propagation areas by drainage.
(*c*) Attacks on propagation areas by oiling.
(*d*) Attacks on propagation areas by larvacides.
(*e*) Attacks on propagation areas and adult mosquitoes by natural enemies.
(*f*) Attacks on propagation areas by clearing bodies of water.
(*g*) Attacks on propagation areas by removal of jungle.

A full discussion of each and every one of these methods of attack lies outside the plan and scope of this plea. It is self-evident, however, that each and every method is governed by special local conditions, which require to be ascertained by means of strictly scientific surveys, including considerations of both malaria frequency and mosquitoes in their relation to topographic features, meteorological conditions and artificial circumstances, such as impounded waters, which have been made a subject of special consideration in a report of the United States Public Health Service. Each method of attack is thoroughly described in the work of LePrince and Orenstein, and amplified by details of actual experience and supplemented by statements of practical results.*

Most of the methods of attack on anopheles propagation areas involve superior considerations of drainage and reclamation. It is, therefore, of the first importance that there should be complete and hearty cooperation between all local efforts at malaria eradication and the plans and purposes of drainage commissions and other public bodies of an engineering character, chiefly, of course, such as have to do with the building and control of waterways, levee-building, hydroelectric plants, etc.

4. Screening and practical destruction of adult anopheles in houses: In the absence of measures and means for the practical elimination of malaria-carrying mosquitoes as an essential prerequisite to malaria eradication, the screening of houses and work-places is unquestionably of very considerable value. Unless such screening, however, is complete, it may be more of a hindrance than a help. Only the best kind of screens is advisable for permanent structures. The 18-mesh screen is recommended by the Panama sanitary authorities.† Special methods are urgently advised in the case of railroad construction camps, and thoroughly well-screened cars used for the housing of laborers should be insisted on by the authorities. As observed by LePrince and Orenstein, "The crucial point about screening is the thoroughness with which the work is done, and the constant vigilance and care that must be exercised in speedily detecting and remedying defects." They point out, however, that even "a perfectly screened house may yet offer innumerable avenues for the entry of mosquitoes," and they therefore, by inference, suggest the prior importance of the complete destruction of anopheles propagation areas.

*On the relation of impounded waters to the prevalence of malaria, two publications have been issued by the United States Public Health Service, reprint No. 244, by H. R. Carter, and reprint No. 257, by J. A. LePrince, Washington, 1915.

†The subject of screening in relation to the practical destruction of adult anopheles in houses is fully described in Chapter xv of LePrince and Orenstein's work on "Mosquito Control in Panama," 1916.

5. On the possibilities of the reduction of domestic mosquitoes, a concise treatise has been published by Edward Halford Ross, for the purpose of providing instructions for the use of municipalities, town councils, health officers, sanitary inspectors and residents in warm climates.* After directing attention to the pathological importance of domestic mosquitoes and restating the biological considerations of mosquito life and propagation, Ross suggests as a first requirement "a fever census," for he observes, "unless the state of health of the town is known before the sanitary reform is begun it will be impossible to obtain comparative statistics and there will be no means of showing what the results are." Following the fever census, a further requirement is an approximate estimate of the cost of mosquito reduction and an outline of the ways and means to be followed. The financial considerations are, of course, of the first importance in localities where extensive engineering measures may be required. Accurate statistics of previous malaria frequency are, therefore, necessary in support of the plea for continuance of municipal or state expenditures made in behalf of mosquito reduction and malaria eradication.† Ross warns against unnecessary extravagance, and he properly observes that, while mosquito reduction is not an expensive measure, it can not possibly be done for nothing. The cost, of course, varies widely in different localities, and no general average unit of cost can be relied upon. The entire project of malaria eradication, in his words, rests upon the fundamental principle "that it is the duty of the state to undertake permanent reforms that lead to health." Since erroneous conclusions are the rule rather than the exception, it is suggested that the ascertainment of local mosquito density be made during the period of maximum density, or immediately after heavy summer rains. The extent of the water surface likely to be utilized for breeding purposes should be ascertained, and at the same time the number of garden fountains, water-butts, cisterns, ponds, garden puddles and pools should be counted and "the presence of mosquito larvae or pupae in them observed" should be written down. A house-to-house examination is absolutely essential, and without such an inspection, and reinspection and constant supervision, the sanitary results of the Panama Canal Zone administration would have been impossible.

Granting, in the words of Edward Halford Ross, that "the best larvacide for mosquitoes is the abolition and prevention of stagnant water collection," it is a foregone conclusion that the second best method is the more or less extensive use of oil.‡ The technical considerations of this

*"The Reduction of Domestic Mosquitoes," by Edward Halford Ross, Philadelphia, 1911.

†Reference may appropriately be made to a sickness survey of North Carolina by the Metropolitan Life Insurance Company, published in New York, 1916. The results of this survey can not be relied upon for the present purpose, in that the investigation was made during the month of April, when malaria as the most important disease in the coast counties would naturally be of a very much lesser degree of frequency than during the months of August and September.

See in this connection reprint 217 of the United States Public Health Service on "Mosquitoes and Malaria in Eastern North Carolina," by Chas. W. Stiles, Washington, 1914.

‡The general question of oiling as an anti-mosquito measure is discussed by J. A. LePrince in reprint No. 260 of the United States Public Health Service, Washington, 1915.

aspect of mosquito eradication are much more complete than is generally assumed to be the case, and failure frequently has resulted from indifference to fundamental considerations. Any and all of these aspects are much more involved than is apparent upon superficial consideration, and in its final analysis the required results, if they are to be permanent, must rest upon a thoroughly well-considered scientific plan of local health administration and sanitary control. Wherever malaria has in part been eradicated, as, for illustration, in certain localities of the Federated Malay States, on the Panama Canal, on the Suez Canal and in Khartoum, the results achieved have been in consequence of *a thoroughly organized local health administration*, with sufficient powers to eliminate the risk of flagrant individual violations of laws, rules and regulations intended solely for the common good.*

Restating the conclusions of Edward Halford Ross, the plan of campaign for the reduction of domestic mosquitoes may be summed up in the axiom, which he suggests should be published broadcast: *No stagnant water.* This axiom, when applied to the concrete problem of mosquito eradication, is, however, often an almost insuperable initial obstacle. The exact ascertainment of all places where stagnant water exists, including holes in trees, railway ditches, ornamental ponds, large and small water-tanks, bilgewater on barges, etc., involves many practical difficulties. As observed by Ross, "Thousands of mosquitoes may be produced from a single saucer of water within three weeks, and neglect, therefore, in matters of small detail may be followed by lamentable consequences." As shown, however, in Panama and elsewhere, the practical eradication of malaria is attainable at reasonable expense, and certainly so under the less than semi-tropical conditions common to most of the Southern States. In strictly tropical countries, with a very heavy rainfall and a very high average range of temperature and humidity, the difficulties, of course, are more serious. Even, however, under the most trying conditions of extreme tropical life, results have been achieved which would have been considered absolutely impossible even a few years ago. Mosquito and malaria eradication efforts have occasionally failed, and even disastrously so in some conspicuous instances, but the general principles of radical measures are now so thoroughly understood that there is no more reason for the endemic continuance of malaria than for that of yellow fever, typhoid fever, cholera or plague.†

6. The most modern conceptions of malaria and the transmission of disease were restated by Sir Ronald Ross, in his Huxley Lecture of 1914, reprinted in the *Scientific American Supplement* for January 23, 1915. After considering that it was only in 1880 that Laveran made the

*Permanent progress in malaria eradication depends, of course, in a large measure, upon sanitary progress in general. The close relation of sanitary problems to many other medical problems is best illustrated in the admirable report, by Prof. W. J. Simpson, on Sanitary Matters in Various West African Colonies, published as Parliamentary paper Cd. 4718, London, 1909. The results of effective sanitary measures are brought out in the vital statistics of non-native officials serving in British West African colonies. The returns for 1914 were issued as a Parliamentary paper, Cd. 7871, London, 1915.

†See "Sanitation in Panama," by Wm. C. Gorgas, M. D., New York, 1915.

important discovery that malaria was invariably associated with a minute protozoal parasite of the blood, it is not discouraging that a larger measure of progress in malaria eradication should not have been achieved during so comparatively short a period of time, considering the extensive prevalence of the disease throughout the ages of the entire historic period. Sir Ronald Ross properly refers to malaria as certainly the most important disease in the tropics, and perhaps in the world. Even 500 years B. C., he points out, the ancients were acquainted with the fundamental law of malaria—that is, its connection with stagnant water such as marshes, etc., but even at the present time the population generally is indifferent to stagnant water and promiscuously permits the continuance of breeding-places in localities and sections where it is perfectly obvious that, because of such neglect and indifference, malarial disease is the causative factor, directly or indirectly, of most of the ill-health afflicting the community. Ross commenced his malaria investigations on the theory of mosquito transmission at the suggestion of Sir Patrick Manson in 1896-1897, and in 1897 he finally correctly ascertained the true causative factor in the disease. The discovery itself did not become common knowledge until about 1898, so it is practically only about eighteen years that the mosquito transmission of malaria has been generally accepted and generally understood.* Once that the principle was clearly established, the conclusion, as summarized by Sir Ronald Ross, became entitled to unconditional acceptance: "We now have a great sanitary ideal put before us—so to manage our habitations, villages, towns, and cities that the vermin in them shall be reduced to the lowest possible figures. Scores of entomologists and medical men are now dealing exactly with the habits of these creatures and showing us how to effect the required object. It demands only intelligence, energy, and organization on the part of administrators. Unfortunately these qualities are not always forthcoming, and administration often lags years behind the dictates of science."† Regardless of all that is known concerning malaria transmission through the mosquito and the absolute urgency of effective measures of eradication and control, Sir Ronald Ross is unhappily justified in his final conclusion that "Although fifteen years have elapsed since many of the facts which I have described were discovered, I think that I may say after constant study of the subject, and with all due consideration, that *mankind has hitherto not effected more*

*An exceptionally suggestive illustration of the most effective dissemination of trustworthy information on malaria is to be found in an outline of less than two pages in the "First Course in General Science," by F. D. Barber and others, Henry Holt & Co., New York, 1916. The most convenient general discussion of malaria for lay readers is Farmers' Bulletin 450, issued by the United States Department of Agriculture, for gratuitous distribution, entitled "Some Facts About Malaria," by L. O. Howard, Ph. D., Washington, 1916.

†The following are the most useful sources of modern knowledge regarding malaria with special reference to tropical countries: "The Diseases of Warm Countries," by B. Scheube, London, 1903, "Manual of Tropical Medicine," by Castellani and Chalmers, 2d Ed., New York, 1913, "Tropical Diseases, a Manual of the Diseases of Warm Countries," by Sir Patrick Manson, 5th Ed., New York, 1914, "Tropical Hygiene for Residents in Tropical and Sub-Tropical Countries," by Sir Pardey Lukis, 3d Ed., Calcutta and London, 1915, "Health Preservation in West Africa," by J. Chas. Ryan, London, 1914, "The Principles of Hygiene as Applied to Tropical and Sub-Tropical Climates," by W. J. R. Simpson, London, 1908, and the article "Malaria," by R. H. von Ezdorf, in a Reference Handbook of the Medical Sciences, Vol. vi, New York, 1916.

than about one-tenth of the improvement of health which it might have effected already if it had put its heart into the business."

This is precisely *the problem as it concerns the United States and, in fact, the entire western hemisphere*, wherever the incidence of malaria is of measurable proportions at the present time. As observed by Major-General Gorgas, in his address on the sanitary organization of the Isthmian Canal as it bears upon antimalarial work, "though there has been much antimalarial prophylaxis in the United States since anopheles have been demonstrated to be the carriers of the plasmodium, this disease is yet far from being eliminated, especially in the South," and he states with reference to malaria eradication that "lack of success in any community must mean that the *modus operandi* has been inadequate and imperfect, the fault generally being that details have been neglected or ridiculed as too trivial for attention." As well said in the *Scientific American* of December 7, 1912, with reference to the address of Dr. Gorgas, "When malaria can be practically extinguished in such a region as the Panama Canal Zone,* the same thing can be done practically anywhere else," and Gorgas's fundamental principles, in the order of their importance, are enumerated as "(1) the habitat of anopheles during the larval stage is destroyed within a hundred yards of dwellings, since the larvae of this mosquito live only in clear, fresh water, which is plentifully supplied with grass and algae; (2) all protection for the adult mosquito must be destroyed, since the adult is weak on the wing, not generally flying far and needing plenty of grass and brush for protection against the wind;† (3) all habitations are screened, but effectively, for screens as ordinarily put up without expert supervision are of little use; (4) when breeding-places can not be destroyed by drainage, the larvae must be destroyed by means of crude petroleum, or some other larvacide." These are principles not difficult of application, but they require an active interest on the part of the community in clear realization of the fundamental concept that the health of the nation is the wealth of the nation, and that health squandered ruthlessly and recklessly is even

*The following table will show in an abbreviated form the very material reduction in the malaria morbidity and mortality rate among Isthmian Canal Zone employees during the period of American construction. The rates are subject to the qualification that they are based on the number of names on the payroll and not on the true average number of persons employed.

Year	Average Number of Employees	Deaths from Malaria		Hospital Cases of Malaria	
		Number	Rate per 10,000 Employees	Number	Rate per 100 Employees
1906	26,547	233	87.8	21,739	81.9
1907	39,343	154	39.1	16,753	42.6
1908	43,890	73	16.6	12,372	28.2
1909	47,167	52	11.0	10,169	21.6
1910	50,802	50	9.8	9,487	18.7
1911	48,876	47	9.6	8,987	18.4
1912	50,893	20	3.9	5,623	11.0
1913	56,654	21	3.7	4,284	7.6
1914	44,329	7	1.6	2,886	6.5
1915	34,785	9	2.6	1,570	4.5
1916	33,176	3	0.9	493	1.5

†The malaria morbidity and meteorological statistics of the Panama Canal Zone with special reference to wind force indicate a pronounced negative correlation and apparently prove that the rate of incidence rises or falls in inverse proportion to wind force.

worse than the unpardonable waste of natural resources and accumulated material possessions. As pointed out in an editorial of the *Journal of the American Medical Association* on malaria and the development of the South, after directing attention to the measures and means adopted for the possible control of hookworm and pellagra, "Recent agitation and information concerning these two diseases have placed them in the limelight almost to the exclusion of the older and better known disease, malaria, which is still a tremendous menace and handicap to industrial progress." Attention is also directed to the interest in the subject on the part of the Southern Medical Association, as shown by the appointment of a special commission, of which Capt. Charles F. Craig, of the Army Medical School, was made the chairman, and which, among its membership, included Dr. C. C. Bass, the discoverer of the method of cultivating the malarial plasmodium.* In concluding the editorial, it was said that the work of this commission, which originated wholly within the medical profession, should be of inestimable benefit to the South, and that it should be encouraged and supported by the local and national governments until malaria in the South had been as completely exterminated as yellow fever. This, it was held, was possible, but a much greater and more expensive task than the eradication of the former disease, and the burden of it should, therefore, be borne by the whole people. The work of the commission was tentative and inconclusive, because the necessary support, financial and otherwise, was not forthcoming, nor was the required governmental cooperation, whether federal, state or municipal, secured to the degree essential to the attainment of substantial results.

The dawn of a new era: It was in profound appreciation of these facts that a *new plan of procedure* seemed advisable, and in fact necessary, for the purpose of carrying into effect the following important resolution unanimously adopted by the Second Pan-American Scientific Congress:

> The Second Pan-American Scientific Congress, recognizing that the education of the public in the elementary facts of malaria is of the utmost importance, requests that—
>
> The American Republics inaugurate a well-considered plan of malaria eradication based upon the recognition of the principle that the disease is preventable to a much larger degree than has thus far been achieved.

It is said in the official text, in explanation of the resolution, that it was pointed out, in the discussions of the section on Public Health and Medical Science, that "in semi-tropical and tropical regions of the western hemisphere the supreme importance of malaria as a problem of public health was recognized by all governmental, medical, and sanitary authorities," and that "it was stated by competent authorities that the economic loss due to the prevalence of malaria could be overcome by diminishing the mortality; that the loss occasioned by mortality due to malarial fever was one of the most serious evils affecting the health

*A concise presentation of the general malaria problem by Chas. C. Bass was contributed to the Commemoration Volume of the American Medical Association, Chicago, 1915.

and happiness of the people, and that the problem [of malaria eradication] in all its aspects had not yet received the amount of public interest and scientific investigation commensurate with its world-wide importance."* This resolution, unanimously adopted by one of the most important international gatherings ever held in the United States in behalf of the furtherance of the cause of more amicable relations between the American Republics marks a milestone in human progress, for it is inconceivable that the nations which have pledged themselves to this rule of action will ever prove neglectful of or indifferent to the principle thus enunciated and the practical solution thus proposed, for the ultimate betterment of living conditions throughout a vast portion of the western world. All the fundamental elements of malaria eradication are now thoroughly understood and they require only to be made public property in the broadest possible sense. The apathy of governments and of communities require to be shattered by an appeal to the conscience, the intelligence, the self-interest of the people concerned. The elementary facts of the disease are readily within the comprehension of even persons of less than average intelligence, and they can be brought within the public understanding, even on the part of school-children, as best illustrated by the admirable manual published by the Philippine Board of Health.† A common-sense descriptive account of the transmission of the disease by malaria-carrying anopheles should be made available as a part of the curriculum of every public school in the Southern States, and every child should have accurate knowledge of the local species of disease-carrying mosquitoes most detrimental to health and life.‡ Aside from the intellectual interest thus aroused in the study of natural phenomena, the child gradually would acquire an active and wholesome interest in the broader questions of public health and sanitary science, for it is these that will form the cornerstone of a better national life than we have heretofore known, and through these that countless years of life will be saved to the community, to the enormous social and economic advantage of all concerned. Measurable human progress consists not only in the accumulation of material wealth, however vast, in inventions, however marvelous, or intellectual attainments, however astonishing, but as much, if not more, in the lengthening of human life, in the elimination of needless disease, in the prevention of useless accidents and in the consequential increase in real human happiness, obtained through the realization of a distinctly higher level of genuine civilization.§

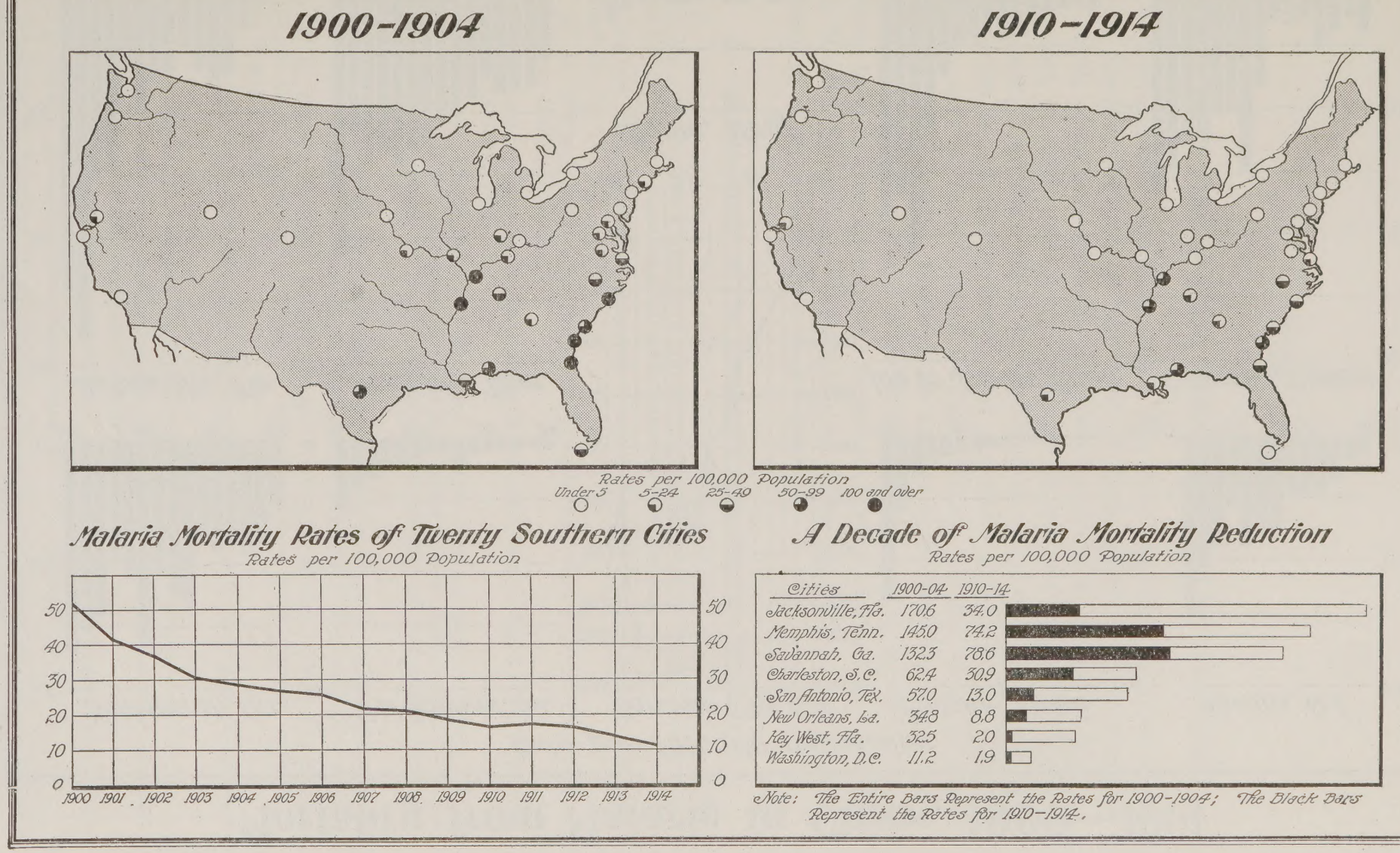
*"The Final Act and Interpretative Commentary Thereon," Second Pan-American Scientific Congress, by James Brown Scott, LL. D., Washington, Government Printing Office, 1916, p. 129 *et seq.*

†See "Sanitary Inspectors' Handbook," by Carroll Fox, M. D., Government of the Philippine Islands, Department of the Interior, Bureau of Health, Manila, 1913, pp. 64-67, 149, 163-164.

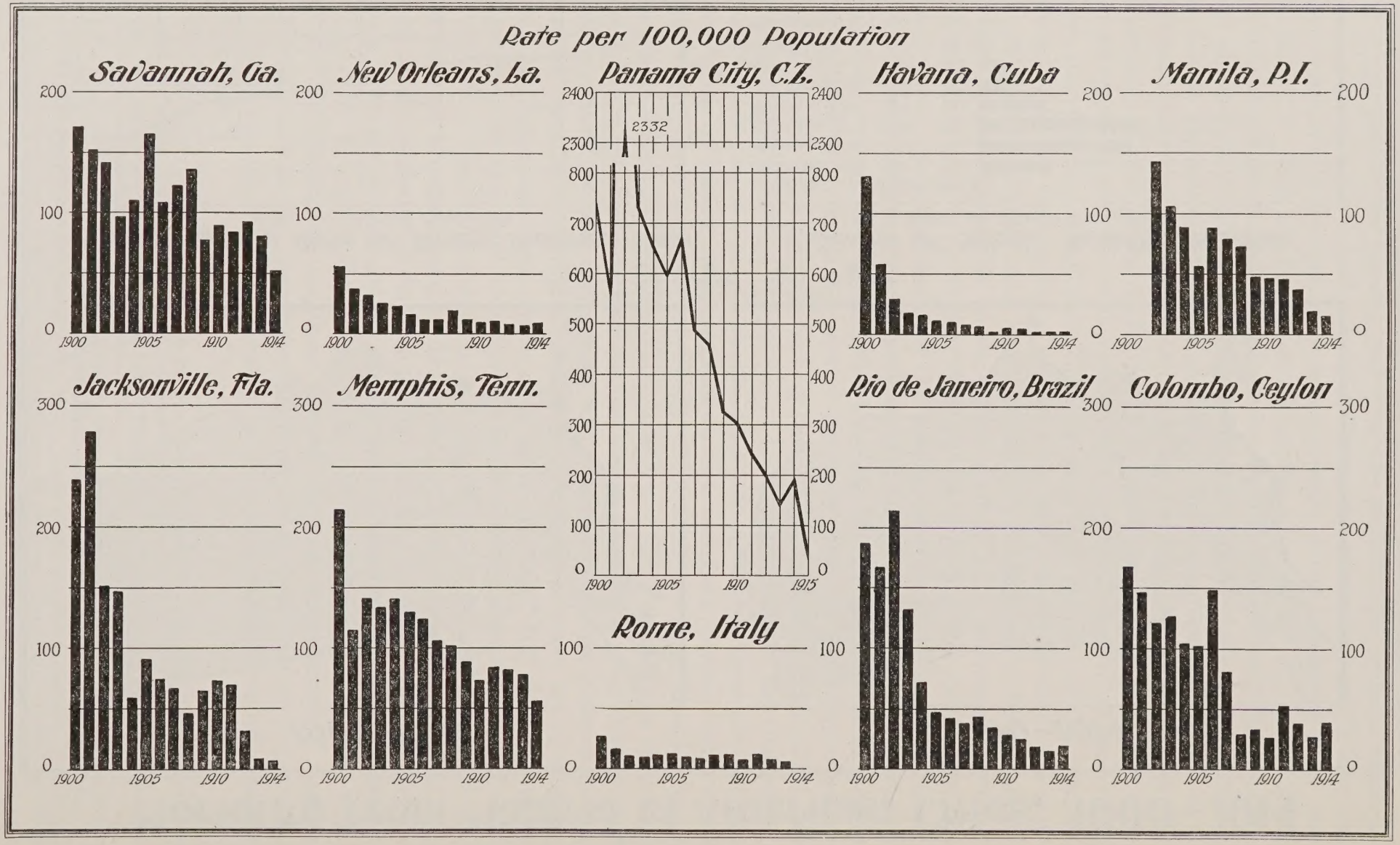
‡"Malaria, Lessons on Its Cause, Prevention," etc., for use in schools, by H. R. Carter, United States Public Health Service, Supplement No. 18 to the Public Health Reports, July 17, 1914, 3d Ed., Washington, 1916.

§Considerable information of practical value in the study of the economic importance of preventive medicine will be found in my address on "The Significance of a Declining Death Rate," Transactions First National Conference on Race Betterment, Battle Creek, Mich., 1915.

Mortality from Malaria in American Cities, 1900–1914



Mortality from Malaria in Cities, 1900—1914



PART II

A PLAN FOR ORGANIZED PREVENTION AND CONTROL

A well-considered working plan for the gradual eradication of malarial diseases throughout the western hemisphere must necessarily be the result of an exceptionally qualified, active and continued interest on the part of each and every member of the National Committee. The following tentative plan, worked out in some detail, with a due consideration of all the interests and activities more or less directly concerned, may be found useful in the ultimate perfection of the final program of the National Committee in the direction of a broadening of the original plan and scope of the Committee's work as agreed upon at a meeting held in the office of the Surgeon-General of the United States Public Health Service at Washington on May 10, 1916. The charter membership of the Committee is as follows:

I. Membership of the National Committee on Malaria

Dr. C. C. Bass, Medical Department, Tulane University of Louisiana, New Orleans, La. (Scientific Director of the experimental malaria eradication work in Mississippi of the International Health Commission.)

Dr. Rupert Blue, Surgeon-General, United States Public Health Service, Washington, D. C.

Dr. W. E. Britton, State Entomologist, Connecticut Agricultural Experiment Station, New Haven, Conn.

Dr. H. R. Carter, United States Public Health Service, United States Marine Hospital, Baltimore, Md.

Capt. Chas. F. Craig, M. D., Medical Corps, United States Army, Fort Leavenworth, Kans. (Late member of the United States Army board for the study of tropical diseases in the Philippines and author of "Malarial Fevers," New York, 1909.)

Dr. Wm. H. Deaderick, Hot Springs, Ark. (Joint author, with Lloyd Thompson, M. D., of "Endemic Diseases of the Southern States," Philadelphia, 1916.)

Dr. W. E. Deeks, General Medical Superintendent, United Fruit Company, New York City. (Formerly Chief of the Medical Clinic, Ancon Hospital, Panama Canal Zone.)

Dr. Oscar Dowling, President of the Louisiana State Board of Health, New Orleans, La.

Major-General W. C. Gorgas, United States Army, Washington, D. C.

Dr. Frederick R. Green, Secretary of the Council on Health and Public Instruction, American Medical Association, Chicago, Ill.

Dr. Seale Harris, Editor of the *Southern Medical Journal*, Birmingham, Ala.

Dr. Thomas J. Headlee, State Entomologist, New Brunswick, N. J.

Dr. Graham E. Henson, State Board of Health, Jacksonville, Fla. (Author of "Malaria, Etiology, Pathology, Diagnosis, Prophylaxis," St. Louis, 1913.)

Frederick L. Hoffman, LL. D., Statistician The Prudential Insurance Company of America, Newark, N. J.

L. O. Howard, LL. D., Chief of Bureau of Entomology, United States Department of Agriculture, Washington, D. C.

Mr. Arthur Hunter, Actuary The New York Life Insurance Company, New York City. (President Actuarial Society of America.)

Dr. W. D. Hunter, Bureau of Entomology, United States Department of Agriculture, Washington, D. C.

Dr. J. W. Kerr, Assistant Surgeon-General, United States Public Health Service, Washington, D. C.

Dr. W. S. Leathers, Director of Public Health, Jackson, Miss. (Administrative Director in charge of the malarial eradication work in Mississippi of the International Health Commission.)

Mr. Joseph A. LePrince, C. E., A. M., United States Public Health Service, New Orleans, La. (Late Chief Sanitary Inspector, Isthmian Canal Commission, and author of "Mosquito Control in Panama," New York, 1916.)

Dr. Charles F. Mason, Medical Corps, United States Army. (Late Chief Health Officer, Panama Canal Zone.)

Dr. J. Y. Porter, State Health Officer, Jacksonville, Fla.

Dr. W. S. Rankin, State Health Officer, Raleigh, N. C.

Dr. M. J. Rosenau, Harvard Medical School, Boston, Mass. (Author of "Preventive Medicine," New York, 1913.)

Dr. E. R. Stitt, Medical Inspector, United States Navy, Washington, D. C.

Dr. John M. Swan, Rochester, N. Y. (Secretary American Society for Tropical Medicine.)

Dr. W. S. Thayer, Baltimore, Md. (Joint author, with John Hewetson, M. D., of "The Malarial Fevers of Baltimore," Johns Hopkins Hospital Reports, 1895, and author of "Lectures on the Malarial Fevers," New York, 1897.)

R. H. von Ezdorf, Surgeon, United States Public Health Service, New Orleans, La. (Since deceased.)

Dr. Robert Wilson, Jr., President of the South Carolina State Board of Health, Charleston, S. C. (Late President of the Southern Medical Association.)

II. General Plan of Organization

The administrative direction of the work of the Committee is to be in charge of an Executive Committee, consisting of an Honorary Chairman, an Active Chairman, a Secretary and the Chairmen of the Subcommittees, a majority of whom shall constitute a quorum.

It is recommended, but at present not provided for, that state committees be formed in each and every state in which malaria exists as a serious public-health problem.

The general objects, plans and purposes, and the organization of the National Committee, in detail, as agreed upon at the Washington meeting on May 10, 1916, are as follows:

Objects of the Committee. The plan and scope of the Committee shall be:

(*a*) To stimulate the scientific and public interest in malaria problems.

(*b*) To serve as a medium through which societies and individuals may become identified with the study and prevention of malarial diseases.

(*c*) To coordinate the efforts of these agencies with those of constituted federal, state and local authorities.

Character of the Organization. The Committee shall be a voluntary organization, its members shall serve without compensation, and there shall be no membership dues.

Membership. Persons who have accepted membership (at the time of organization) shall be known as charter members.

The executive officers of the state boards of health of states in which malaria exists as a serious public-health problem and state officers charged with the enforcement of laws for the suppression of disease-bearing mosquitoes are invited to become members of the Committee. Others interested in the objects of the Committee may from time to time become members by vote of the Committee.

Meetings. There shall be a meeting of the Committee held once annually at the call of the Chairman at such time and place as he may deem most suitable. Special meetings may be had, however, on the call of the Chairman.

Officers. The executive officers elected at the meeting on organization are Honorary Chairman, Major-General W. C. Gorgas, Active Chairman, Dr. Rupert Blue, and Secretary, Dr. Seale Harris.

The work of the National Committee is divided among the following six subcommittees:

(1) Administration.
(2) Entomology.
(3) Medical Research.
(4) Education and Publicity.
(5) Sanitary Engineering.
(6) Statistics.

III. General Functions of Subcommittees

The specific functions of the subcommittees, in detail, are given below:

Administration. The duties of this committee shall be to encourage:

(1) The organization of the state committees in affiliation with the National Committee.

(2) The adoption of antimalarial measures by communities.

(3) Malarial surveys and demonstration of antimalarial work in suitable communities.

(4) Cooperative effort in malarial work.

Entomology. The duties of this committee shall be to encourage:

(1) Mosquito surveys.
(2) Mosquito collections.
(3) Studies of entomological factors in the malaria problem.
(4) Mosquito bionomics.

Medical Research. The duties of this committee shall be to encourage:
(1) Studies of the life history of the malarial parasite.
(2) Its effects on man.
(3) Means for its destruction in man.

Education and Publicity. The duties of this committee shall be:
(1) To encourage the teaching of the facts of malaria and its control in the schools and as far as may be possible to standardize the subject-matter and the methods of so doing.
(2) To encourage the discussion of malaria in medical societies and other interested bodies.
(3) To arrange for popular lectures on malaria to adults and to school-children.
(4) To interest the public press and encourage it to carry on publicity campaigns on malaria.

Sanitary Engineering. The duties of this committee shall be:
(1) To encourage the employment of skilled sanitary engineers by communities contemplating drainage and other engineering measures for the control of malaria.
(2) To confer with those engaged in drainage or impounding projects, so as to obviate the establishment of disease-breeding areas.

Statistics. The duties of this committee shall be:
(1) To encourage states and minor civil divisions to record and report cases and deaths from malaria by localities.
(2) To standardize methods of tabulation to be used for this purpose.
(3) To encourage the collection of data relating to the economics of malaria.

IV. Ways and Means

In the furtherance of the objects and purposes of the National Committee on Malaria Eradication, it would seem urgently advisable that there should be introduced into Congress a bill making provision for adequate federal support on a cooperative basis, more or less in conformity to an act of the Sixty-third Congress, which provides for cooperative agricultural extension work. The sanitary cooperative act may be made all inclusive or specifically limited to malaria eradication and control. If made all inclusive, the basis should be on the principle of proportionate contributions, with a due regard to both area and rural population.* No federal financial support should be forthcoming until the states and counties concerned have provided twice the amount required. In other words, if the federal appropriation, on the basis of a given population, for a given area is, say, $10,000 per annum, this amount should not be available until $20,000 has been provided through the local authorities. Since rural sanitation generally is so very closely

*Recommendation based on original suggestion by Dr. W. S. Rankin at Southern Health Officers' Conference, Washington, D. C., January 29, 1917.

related to malaria eradication, at least in the Southern States, it would probably be advisable, as a practical consideration, to make the congressional appropriation available for sanitary purposes generally, rather than for malaria eradication alone. The general supervision of such federal expenditure should, of course, be under the direction of the Surgeon-General of the United States Public Health Service, who should make the federal allotment upon the recommendation of the Governor of the State and the Secretary of the State Board of Health, after the required local appropriation had been provided for. In the words of the Secretary of Agriculture, "the Extension Act is one of the most striking educational measures ever adopted by any government," but of even greater practical importance would be a sanitary extension act especially applicable to rural communities. The Agricultural Extension Act not only provides for active cooperation between the states and the federal government, but "it guarantees a coordination of the two forces of the two jurisdictions. It places the brains of the two great agencies in conjunction, eliminates waste and friction, and insures efficiency." The act provides for a gradually increasing appropriation without any further legislation. Considering the enormous practical value of such legislation in the furtherance of intelligent agricultural development, it requires no argument to sustain the conclusion that a similar extension act in the direction of sanitary and general public-health problems would prove productive of far-reaching results to the public at large. Every state in the Union through its proper authority has accepted the provisions of the Agricultural Extension Act, and it is a foregone conclusion that there would be a similar cooperation on the part of all of the states in regard to the plan of federal and state sanitary cooperation. Aside from such direct financial support in the development of rural sanitation, it is urgently to be desired that a sufficient amount should be made available to the Federal Public Health Service for malaria research and demonstration work. An appropriation of not less than $100,000 per annum should be made as a guarantee for the continuance of the admirable work which is at present being done by the Federal Public Health Service in this important direction. Malaria as a public-health problem is of such vast importance to the Nation, that it might also be considered advisable to provide for the establishment of a permanent Federal Board for Malaria Eradication, consisting of the Surgeon-General of the United States Army, the Surgeon-General of the United States Public Health Service and the Secretary of the Department of Agriculture.

Of special interest in connection with this suggestion is the enactment of a law (156) by the Sixty-fourth Congress providing for federal aid to the states in the construction of rural post roads and for other purposes. The initial appropriation under this act is $5,000,000; for the year 1918 the sum appropriated is $10,000,000; for the year 1919, $15,000,000;

for the year 1920, $20,000,000, and for the year 1921, $25,000,000. The federal appropriation to the states becomes available on the required amount being certified to by the State Highways Department and the State Governor. Any state desiring to avail itself of the benefits of this act through its State Highways Department is required to submit to the Secretary of Agriculture such a project statement, setting forth the proposed construction of any rural post road or roads, service, plans, specifications and estimates, as the Secretary of Agriculture may require. In much the same manner an appropriation for federal sanitary cooperation could be carried into effect under the immediate direction of the Federal Public Health Service, the State Board of Health and the State Governor.

V. Federal Departmental Cooperation

The keynote of an active federal campaign against malaria is the clear recognition of the supreme importance of the most effective and active cooperation of federal governmental department chiefs, including among those essential to the purpose:

(*a*) The Surgeon-General of the United States Army.
(*b*) The Surgeon-General of the United States Navy.
(*c*) The Surgeon-General of the United States Public Health Service.
(*d*) The Chief of Engineers of the United States Army.
(*e*) The President of the Mississippi River Commission.
(*f*) The Director of the United States Geological Survey.
(*g*) The Director of the United States Reclamation Service.
(*h*) The Director of the Office of Public Roads and Rural Engineering.
(*i*) The Chief of the United States Weather Bureau.
(*j*) The Chief of the United States Bureau of Soils.
(*k*) The Chief of the United States Bureau of Entomology.
(*l*) The Chief of the United States Bureau of Fisheries.
(*m*) The Chief of the Division of Vital Statistics United States Census.
(*n*) The Chief of the States Relations Service.
(*o*) The Federal Farm Loan Board.
(*p*) The United States Commissioner of Labor Statistics.

VI. Pan-American Cooperation

In view of the fact that the official text of the resolution of the Second Pan-American Scientific Congress (Article 39) suggests that

> The American Republics inaugurate a well-considered plan of malaria eradication, based upon the recognition of the principle that the disease is preventable to a much larger degree than has thus far been achieved.

It is implied and required that there should be the most hearty cooperation between the American Republics as officially represented in the United States by the Director-General of the Pan-American Union, particularly in the direction of the most effective publicity of all important matters relating to the suggestions and recommendations of the National Committee for the information of the Latin-American countries

through the medium of the *Monthly Bulletin of the Pan-American Union*. In addition thereto, the assistance of the Chief of the Division of Latin-American Affairs of the Department of State might be enlisted in behalf of an effort to bring about the cooperation of the American Republics agreed upon as desirable and essential in the resolution referred to. It is, furthermore, self-evident that the subject of malaria eradication should engage the most serious attention of the International Sanitary Congress at its forthcoming session and that adequate provision should be made sufficiently in advance to provide for the most thorough scientific consideration of the problem of malaria eradication in its international aspects at the Third Pan-American Scientific Congress agreed upon to be held in Lima, Peru, in 1920.*

The first of the Pan-American Governments to make provision for malaria eradication is the Republic of Peru. According to a recent law passed by the Peruvian congress and approved by the president, subsequently to be enlarged upon by state regulations, malaria-eradication measures will be classified in four sections, namely, the treatment of patients, the protection of people living in places where malaria is recognized as endemic, the destruction of mosquitoes and the drainage or special treatment of swampy lands. According to a report of the Bureau of Domestic and Foreign Commerce, the Peruvian Government, in connection with the antimalaria campaign, "will import annually such a quantity of quinine as may be considered necessary, and this drug will be imported free of all customs duties and port charges. Individuals and institutions may purchase quinine of the Government at cost price for their own use and for the treatment of persons under their charge. All proprietors of estates, all railways, corporations, and other organizations employing labor are under obligations to furnish medical assistance to their employees, either directly or through proportionate contributions to charitable dispensaries, and inspectors will be appointed to see that this part of the work receives due attention. Unemployed persons will receive free quinine from the Government. For the protection of persons living in swampy districts, houses must be equipped with mosquito-proof netting, and rice or other crops requiring flooding must not be cultivated within a certain distance of habitations."

According to the same report the Peruvian Government "will at once begin the work of draining the lands where malaria is most prevalent, and all private owners are given from one to four years to complete the sanitation of their lands. Where drainage is impracticable, swamps are to be treated with crude petroleum to destroy insects and their larvae. The Government is authorized to give prizes and honors to

*The plan and scope of the work of the International High Commission do not at present provide for the consideration of health and sanitary problems. It would seem desirable to increase the final program of the commission as set forth in the report of the United States Section on the first general meeting, held at Buenos Aires, April 3 to 12, 1916, by the addition of a fourteenth section, on Public Health and International Quarantine. By means of such a section the subject of malaria eradication in its Pan-American aspects would be appropriately brought to the attention of the respective governments concerned and possibly earlier than at the meeting of the third Pan-American Scientific Congress, in 1920.

proprietors who show the most zeal in putting their lands into good condition. An exhaustive study is to be made of modern irrigation and cultivation systems, with a view to overcoming the farming conditions that lead to malaria. In addition, a course of study on the prevention of malaria is to be introduced in all the public and private schools of Peru. This instruction, as well as the organization and maintenance of the sanitary work, will be in charge of the Department of Public Health, and the expense incurred will be met by annual appropriations in the budget."

The Peruvian Government is entitled to the high honor of having been the first of the Pan-American Republics to carry into actual effect the provisions of Article 39 of the Final Act of the Second Pan-American Scientific Congress, and the results to be achieved under the contemplated measures of eradication should make a most useful and instructive contribution to the proceedings of the Third Pan-American Scientific Congress, to be held in Lima, Peru, in 1920.

VII. State Cooperation

On the part of each of the states most seriously interested in malaria eradication, the problem in its final analysis is chiefly a matter of local concern, and the required funds for such objects and plans as may be deemed advisable must be derived from state and local revenues, except in so far as they may be amplified by corresponding amounts made available through federal appropriations.* It is, however, essential that there should be on the part of each and every state directly concerned the most thoroughly considered cooperation on the part of

(*a*) The State Board of Health.

(*b*) The State Engineering, Drainage or Reclamation Commission.

(*c*) The State Geological Survey.

(*d*) The scientific departments of the State University, useful in the rendering of assistance in the furtherance of the plans of the National Committee.

(*e*) The State Agricultural Experiment Station.

(*f*) The State Medical Society.

VIII. County and Municipal Cooperation

Malaria, in general terms, being largely a local problem, particularly as regards mosquito eradication, it is of the utmost urgency that the most carefully considered cooperation should be had on the part of the counties and municipalities in which malarial disease is known to prevail

*This suggestion is merely tentative. The underlying consideration is the excellent work of the States Relations Service of the United States Department of Agriculture, which represents the Secretary of Agriculture in his relations with State Agricultural Colleges and Experiment Stations, under the acts of Congress granting funds to these institutions for experimental and cooperative extension work in agriculture and home economics, in carrying out the provisions of acts of Congress making appropriations to this department for farmers' cooperative demonstration work, investigations relating to agricultural schools, farmers' institutes and home economics, etc.

to a more or less serious degree. It is therefore suggested as essential that the cooperation of the following should be enlisted:

(*a*) The City or County Board of Health.

(*b*) The City or County Engineer.

(*c*) The Department of Public Works or kindred bodies having to do with sewerage and drainage.

(*d*) Local medical societies.

IX. International, National and Corporate Health-Promoting Agencies

In addition to federal, state and local governmental cooperation, all of the more important international, national and corporate health-promoting agencies should be utilized in the furtherance of the practical, as well as theoretical, work of the National Committee. Of these agencies, the following are of special importance:

(*a*) The International Health Commission (already actively engaged in malarial research and eradication in certain Southern States).*

(*b*) The Carnegie Institution (which has rendered a most conspicuous service to the cause of malaria eradication by the publication of a thoroughly scientific treatise, in four volumes, on "The Mosquitoes of North and Central America and the West Indies," by Leland O. Howard, Harrison G. Dyar and Frederick Knab).

(*c*) The American Public Health Association, especially through the Section on Sanitary Engineering.

(*d*) The Southern Sociological Congress.

(*e*) The American Medical Association.

(*f*) The Southern Medical Association.

(*g*) The American Academy of Medicine.

(*h*) The American Climatological Association.

(*i*) The American Association of Economic Entomologists.

(*j*) The American Microscopical Society.

(*k*) The American Nature Study Society.

(*l*) The American Society of Civil Engineers.

(*m*) The American Museum of Natural History.

(*n*) The American Hospital Association.

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*Extract from Second Annual Report of the International Health Commission, 1916:

"Theoretically, the control of malaria is relatively simple, but as a practical undertaking it has been found extremely difficult. In view of the important interests at stake, however, the International Health Commission is undertaking to carry out an experiment with a view to ascertaining what degree of control may be achieved in our temperate climate within the limits of reasonable expenditure and under the conditions which prevail in typical farming communities in the Southern States. Arrangements have been made to carry out two sets of experiments; one to test the practicability of malaria control by detecting the carriers and freeing them of the parasites; and the other to test the practicability of malaria control by means of a combination of control measures. In neither case is the extermination of mosquitoes by major drainage operations to be undertaken."

X. Education and Publicity

Since all measures and means for malaria prophylaxis must rest primarily for their highest obtainable degree of effectiveness upon the intelligent, most hearty and continued cooperation of the general public,* it is of the first order of importance that qualified assistance should be rendered in behalf of this effort by

(*a*) The United States Bureau of Education.

(*b*) The state, county and municipal educational authorities.

(*c*) The Council on Health and Public Instruction of the American Medical Association.

(*d*) The General Federation of Women's Clubs.

(*e*) The press, whether general, medical or technical, including periodicals and the general press service of the Associated Press, the American Press Association, the International News Service, the United Press Association, etc.

(*f*) The mosquito extermination associations.

(The New Jersey association has held four annual meetings to date and has rendered conspicuous educational services. The proceedings are a most valuable source of useful information. According to an address by Dr. Ulrich Dahlgren, the number of cases of malaria in Princeton, N. J., was, in consequence of local antimalarial measures, reduced from 127 in 1914 to only 8 in 1916.)

XI. Industrial and Other Corporate Business Organizations

(*a*) The Chamber of Commerce of the United States of America. (This body has already indicated its interest in the subject, by the publication of a special bulletin on "Reclamation of Swamp Lands and Conquest of the Malaria-bearing Mosquito," Washington, D. C., October 27, 1916.)

(*b*) Local chambers of commerce and boards of trade.

(*c*) The Southern Commercial Congress.

(*d*) The National Civic Federation.

(*e*) The National Farmers' Congress.

(*f*) The National Rivers and Harbors Congress.

(*g*) The Atlantic Deeper Waterways Association.

(*h*) Southern railway companies and river transportation lines.

(*i*) Steamship companies engaged in Southern coastwise or Latin-American commerce.

(*j*) Life insurance companies and societies transacting business in the Southern States and Latin-American countries.

(*k*) The Life Extension Institute.

*Of considerable practical value is a brief "Summary of Facts Regarding Malaria Suitable for Public Instruction," by Maj. (now Sir) Ronald Ross, published by John Murray, London, 1911. This summary includes a descriptive account of the relation of the parasites to malaria, the mode of infection, the essential facts about mosquitoes, the means of personal prevention and the means of public prevention. The outline concludes with the suggestion that "for further information or assistance the reader should apply to the local sanitary or medical authorities."

XII. An Active Advisory Council

An active advisory council might be formed and made to consist of official representatives of the foregoing and kindred bodies or organizations and agencies useful for the purpose of furthering by their active cooperation or by means of correspondence, etc., the plans and purposes of the National Committee on Malaria. The council should meet with the National Committee at least once a year in the city of Washington, so as to bring about the most satisfactory coordination of federal, state and other interests.

XIII. Some General Methods of Procedure

A. Malarial Surveys and Public Education

Among the more important methods and means in behalf of active efforts at malaria eradication the following are deserving of special consideration:

(*a*) Malaria and mosquito surveys. For an excellent illustration, see Bulletin 189, Connecticut Agricultural Experiment Station, entitled "A Mosquito Survey at the Mouth of the Connecticut River." The special importance of this survey is that the expense of making the same was met by the Old Saybrook Town Improvement Association of Old Saybrook, Conn.

One of the most instructive of the many mosquito surveys made in this country is the Report on Mosquito Investigations, by W. E. Britton and Harry Viereck, in the Connecticut Experiment Station Report for 1904, including observations on the characteristic vegetation, as a guide to the ascertainment of mosquito-breeding areas, and descriptive accounts, illustrated by maps, of the most affected areas in the state. The report concludes with practical suggestions on mosquito control in Connecticut and on the relation of mosquitoes to property values.

An excellent account of modern methods in making anopheles surveys, with extended lists of anopheles breeding-places throughout different health districts of the colony, is contained in the Trinidad Malarial Report for 1914-1915, by Dr. C. F. Lassalle, Trinidad, 1916. Nine different types of breeding-areas are defined, as follows: (1) Slowly running water-courses, streams and rivers, (2) Pools in ravines—ravines are water-courses which are generally dry during the dry season and contain pools during the rainy season, (3) Low-lying swampy and grassy land bordering on extensive mangrove swamps—containing large and small depressions, crab-holes, etc., (4) Rice fields, (5) Ponds, (6) Shallow wells and water-holes, (7) Borrow-pits at the sides of roads and railway lines, (8) "Tapia" holes—holes from which clay is obtained for building huts, (9) Earthen street and road drains improperly graded or blocked. Of special practical interest are the forms

used in the anopheles survey of Trinidad and the instructions to assistant sanitary inspectors.

(*b*) Malarial indices, primarily of children, through the medium of medical school inspection and of factory employees through the physical examination of applicants for work.

Some interesting observations on the methods of obtaining children for spleen examinations, and the practical difficulties to be overcome, are included in the notes on Sumatra in Malcolm Watson's treatise on "Rural Sanitation in the Tropics." In the same work is a brief discussion of erroneous or misleading spleen rates in correlation to malaria death rates in British Guiana. The most important recent contribution to this subject is "The Spleen Census for 1914," of the island of Trinidad, by C. F. Lassalle, acting assistant medical officer of health, in the Trinidad Malarial Report. According to this census the percentage of children with enlarged spleens in the colony was 14.1 per cent. The corresponding percentages obtained for other countries, as given in the report, for comparatively recent years, are 34.1 for Mauritius, 34.1 for Ceylon, and 17.9 for Trinidad and Tobago, during 1913-1914, which, therefore, indicates a decline during the year 1914, when the ascertained percentage, as previously stated, was 14.1. The maximum spleen rate in 1914, for the Oropouche and La Brea districts, was 57.7 per cent. The lowest rate prevailed in the Arima district, or 1.1 per cent. A brief but exceptionally useful practical contribution to American malarial index work is reprint 159, by the late R. H. von Ezdorf, M. D., of the United States Public Health Service, Washington, 1914.

(*c*) Public education, chiefly through the public schools, more or less in conformity to the essential principles of "Malaria, Lessons on Its Cause and Prevention," by Dr. H. R. Carter of the United States Public Health Service, and the broad outlines of malaria prevention as laid down in Bulletin No. 10 of the Medical Series of the University of Missouri, by Prof. Elbert L. Spence.

(*d*) Medical education, in the furtherance of improvements in clinical and microscopical diagnoses of malarial disease, in the more accurate differentiation of the several types of malaria and accuracy in death certification, chiefly with reference to joint causes or diseases in which malaria is a contributory or complicating cause.

B. Free Microscopical Examinations

Public facilities should be provided for the free microscopical examination of the blood for the diagnosis of malaria and the ascertainment of the presence or absence of the malarial parasites, the nature of the pigment and leucocytosis, and the numeric relation of the leucocytes, as laid down in the standard text-books on malaria, and the laboratory examination of the blood.

The practical difficulties of blood examinations are the subject of an extended discussion by the Director of the Wellcome Tropical Research Laboratories, Andrew Balfour, M. D., Gordon Memorial College, Khartoum, in the fourth report of that institution, issued in 1911. The general subject of microscopical examination of the blood in malaria is discussed with admirable brevity in the second chapter of Sir Patrick Manson's treatise on "Tropical Diseases," who observes that "For a thorough appreciation of the principles on which blood examinations for the demonstration and study of the malaria parasite should be conducted, it must be borne in mind that the parasite is intracorpuscular. To *see* it, therefore, it is necessary, particularly for the beginner, so to dispose of the corpuscles in the preparations that a proportion of them shall lie flat on the slide, in a single layer, and presenting their surfaces, and not their edges, to the observer. It is mainly from ignoring this fundamental principle that so many fail to find the parasite."

For the same reason it is particularly urgent that the use of the microscope on the part of practising country physicians should become more general, in fact, universal. It has been said in this connection by Deaderick that

> Before attempting the diagnosis of malaria by the microscopic examination of the blood the beginner must become thoroughly familiar with the appearance of normal blood and with the technic of examination, and he should not rely too much upon the result of an examination until he has had considerable experience with malarial blood.

C. Collection and Preservation of Mosquitoes

Local collections of prevailing species of mosquitoes and their proper preservation, in conformity to the methods of the American Museum of Natural History, are a first essential in the education of school-children and the public as regards the required differentiation of malaria-carrying mosquitoes and mosquitoes harmless in this respect.

The collection and preservation of mosquitoes in conformity to exact scientific requirements are, of course, much more difficult than is generally assumed to be the case. It is also far too generally assumed that most of the required information concerning the geographical distribution of the different species of mosquitoes is already known and that further research is, therefore, unnecessary. An excellent illustration of the results of strictly scientific work in this field is a descriptive account of "New Mosquitoes from the Soudan," by Fred V. Theobald, in the Third Report of the Wellcome Research Laboratory, Kartoum, 1908. A carefully prepared guide-book on "How to Collect and Preserve Insects" was published by Frank E. Lutz of the American Museum of Natural History, New York City, 1915. Attention may be directed in this connection to "Instructions to Collectors of Specimens for the Central Malaria Bureau," drawn up by the Committee for the Study of Malaria in India, published in Simla, 1912, "Notes on the Mosquitoes of the United States," by L. O. Howard, United States Department of

Agriculture, Washington, 1900, and Publication No. VII of the British Museum's Series of Instructions to Collectors of Blood Sucking Insects, London, 1907.

D. Enforcement of Local Ordinances

Antimalarial ordinances and their proper enforcement are matters of most serious concern in connection with any and all efforts at malaria eradication. In New Jersey, according to a report of the United States Public Health Service on Communicable Diseases, "The State Agricultural Experiment Station is required by law to make, at the request of local authorities, an investigation into the causes responsible for the existence of mosquitoes in any locality and suggest measures to abolish them. The local health authorities must be informed of the findings and they in turn are required to notify property owners of their duty to remedy the conditions responsible for the breeding of mosquitoes, and should the owners fail to do this, the local authorities may take the necessary measures, the cost to become a lien on the property." Provision is made in New Jersey for state and municipal cooperation and the appointment in each county of mosquito extermination commissions, the amount of money necessary for the discharge of their duties being included annually in the tax levy. Much valuable additional information concerning law and legislation with reference to insects capable of transmitting disease is contained in the report referred to, as well as in supplementary publications on municipal ordinances, rules and regulations pertaining to public health adopted by cities of the United States having a population of over 10,000 in 1910. A typical ordinance in this connection is the following, adopted by the city of Chattanooga, Tenn., under date of March 10, 1913:

> Be it ordained by the board of commissioners of the city of Chattanooga, Tenn., That it shall be unlawful for any owner, tenant, or agent, in control of any lot or premises within the corporate limits to permit to remain thereon any empty bottles, empty cans, or other receptacles likely to gather and hold water. And any such owner, tenant, or agent, failing to remove all such articles from his lot or premises within five days after notice from the department of health to do so, shall be guilty of a misdemeanor, and upon conviction shall be punished by a fine of not less than $2 nor more than $10 for each offense.

The full text of the New Jersey law with reference to the prevention of the breeding of mosquitoes, adopted under date of May 21, 1912, is republished in the report on state laws and regulations pertaining to public health issued by the United States Public Health Service as reprint No. 200, Washington, 1915.

E. State Drainage Commissions

Active efforts are required in behalf of the establishment of State Drainage Commissions and drainage districts for the earliest possible elimination or reduction of overflowed areas or swamp-lands which under existing conditions are useless for agricultural purposes and a serious menace to health and life.

The principles of engineering for land-drainage and the reclamation of water-injured lands have during recent years been worked out with remarkable thoroughness. Tidal marshes and their reclamation have been reported upon by Mr. George M. Warren, Drainage Engineer of the United States Department of Agriculture, and the same office has issued a suggestive report on "Drainage by Means of Pumps," by S. M. Woodward, Drainage Engineer. A very useful manual on "Drainage and Reclamation of Overflowed Lands" has been issued by the Bureau of Legislative Information of the State of Indiana, and the general subject of the "Drainage of Farm Lands," has been reported upon by C. G. Elliott, Drainage Expert of the United States Department of Agriculture. The general principles of the establishment of a drainage fund are set forth in a report submitted by Mr. Flint, of the Committee on Public Lands, and issued as a Senate Document (Report No. 7342, 59th Congress, 2d Session, 1907). The general subject of drainage has received occasional, but far from sufficient, consideration by the Atlantic Deeper Waterways Association and the National Rivers and Harbors Congress. Perhaps the most important practical work in this direction has been done in the state of Arkansas, as set forth in a Report on the St. Francis Valley Drainage Project in Northeastern Arkansas; but special mention requires to be made of the truly astonishing results which have been achieved under the drainage district laws of the state of North Carolina. A general statement on Swamp and Overflowed Lands in the United States, with reference to ownership and reclamation, by J. O. Wright, Supervising Drainage Engineer, has been issued by the Department of Agriculture, Washington, 1907.*

F. Schools for Tropical Medicine

More adequate support is required for American Schools of Tropical Medicine, for the purpose of providing ways and means for thoroughly specialized scientific investigations of the geographical distribution of malaria throughout the western hemisphere and of the achievements and possibilities of malaria eradication in the countries of Latin America in which the disease is known to prevail to a more or less considerable degree. Increased support is also needed for the more scientific study of blackwater fever and any and all allied tropical diseases increased in frequency or severity on account of being complicated by malaria. †

G. Non-Contiguous Possessions of the United States

The active cooperation of the National Committee with the authorities of the non-contiguous possessions the United States represents an

*See Bulletin No. 38, "Drainage Law of the State of South Carolina," of the State Department of Agriculture, Commerce and Industries, Columbia, 1914. Also, the Proceedings of the Illinois Annual Drainage Conference, under the direction of the College of Engineering, University of Illinois, Urbana, Illinois.

†Of value as convenient sources of trustworthy information are the annual reports of the Advisory Committee of the Tropical Diseases Research Fund, published annually by order of Parliament and containing extended accounts of antimalarial measures and results throughout the British Crown Colonies and Protectorates. These reports are an admirable example of the form in which local governments should annually present the facts of local frequency of malarial diseases and the prevailing or contemplated antimalarial measures for the more effective control or possible eradication of the disease.

important problem. In the furtherance of the cooperative effort for the gradual eradication and more effective control of malarial diseases, it is particularly desirable that the local incidence of the disease in our island possessions should be made the subject of a thorough and strictly scientific inquiry. The malaria problem in our tropical possessions should be considered with the same degree of thoroughness and completeness as has, for illustration, been the case in the investigation into the causes of malaria in Bombay. The service of United States Marines in certain portions of Haiti, San Domingo, Cuba and Nicaragua need only be referred to as a further practical illustration of our increasing interest in the health conditions of the western hemisphere.

H. Meteorological

The more scientific study of the correlation phenomena of malaria occurrence and meteorological conditions is of particular urgency, as best illustrated by the recent contributions of O'Connell on Meteorology and Malaria to the *Journal of Tropical Medicine and Hygiene.* Instrumental observations require to be made with more accuracy and minuteness, and the statistical analysis of the data should be in much more detail than has heretofore been the case.*

I. Statistical Considerations

The statistical analysis of malaria mortality and morbidity data, as well as the correlation of malaria with other diseases, has not heretofore been made with the required degree of thoroughness and attention to detail. As an excellent illustration of the method more or less to be followed, reference may be made to the statistical analysis of data relating to an epidemic of plague in three districts of the Punjab by M. Greenwood, Jr., Statistician to the Lister Institute of Preventive Medicine, also to the report by S. R. Christophers, contributed to the Transactions of the Committee for the Study of Malaria in India, on "Epidemic Malaria of the Punjab, with a Note on a Method of Predicting Epidemic Years." Accurate and conclusive statistics and qualified methods of analysis are of such exceptional importance in malaria investigations that it can not be too strongly urged that this aspect of the problem of the gradual and ultimate eradication of malaria should receive the most thoroughgoing consideration, including a reexamination of the statistical material at present available regarding the geographical distribution of malarial diseases and the variation of incidence according to age, sex, race, occupation, etc.

The Report of an Investigation into the Causes of Malaria in Bombay and the Measurements Necessary for Its Control, by Chas. A. Bentley,

*The most recent contribution by Dr. O'Connell on Meteorology and Malaria, with special reference to malarial fevers, in England appears in the *Journal of Tropical Medicine and Hygiene* for December 15, 1916, in which the atmospheric conditions of Greenwich in August, 1843, are subjected to a minute analysis, since at this time malarial fevers were quite common in the southeast of England, which fact, by Dr. O'Connell, is attributed to the atmospheric conditions, which "were such as would cause pyrexia for a certain number of hours on ten different days." (For more extended observations on meteorology, see pp. 14-16.)

M. D., Bombay, 1911, is one of the most important contributions to the practical question of malaria eradication and control. The report includes extended observations on the methods of measurements of malaria in Bombay by means of the spleen index, blood examination, and analysis of the mortality returns, following a thoroughly scientific discussion of the mosquitoes of Bombay. The conditions which influence mortality are presented in a brief survey, with reference, first, to the anopheline factor and, second, to the human factor. Reference is also made to overcrowding, soil disturbance, migration, education, etc. The prevention of malaria in Bombay is considered with reference to the history of past efforts, the legal aspects of mosquito prevention, the cost of mosquito prevention in different malarial localities throughout the world and finally the cost of permanent measures. Following these observations are sections on the obstacles to malaria prevention, the place of quinine in malaria eradication, and special reasons which make it imperative "that malaria should be eradicated from Bombay." The report is illustrated by a number of instructive maps, diagrams, plates and appendices of climatological and mortality data. No local area in the United States has been investigated and reported upon with a similar degree of thoroughness and scientific as well as practical conclusiveness.

J. Quinine Prophylaxis

On account of the highly specialized nature of the quinine question in its relation to malaria eradication and control, it seems advisable that this matter should be subjected to a thorough reconsideration, with special reference to the experience which has been had during the construction period of the Panama Canal. Of special value, also, is the practical experience in quinine prophylaxis in the island of Jamaica, aside, of course, from the well-known methods and results secured in Italy and in certain sections of India, particularly Bombay.

The controversial aspects of quinine prophylaxis suggest a thoroughly impartial reconsideration of all the available facts. According to Dr. Angus McDonald, in an address before the Society of Tropical Medicine and Hygiene, "Quinine has its position in relief and cure, but in sanitary administration it has none." This rather far-reaching conclusion is amplified in the statement that "continuous drugging with quinine may prevent attacks of malaria in anopheline countries, but statistics are still lacking to demonstrate the extent to which the taking of this drug prevents infection. That the human individual is detrimentally affected by the continued absorption of quinine, be he affected with malaria or not, there can be little doubt. Whatever are the causes of blackwater fever, there seems to be a consensus of opinion that quinine has much to do with it, perhaps more to do with it than malaria has." This conclusion was opposed by Dr. C. F. Hartford, who, with special reference to European missionaries in Central, East and West Africa, points out "that there is good cause for advocating the use of a

daily dose of quinine of five grains, which has in the past produced most important results." The effect of quinine on the malarial parasite, both in mosquito and in man, has been reported upon with admirable scientific thoroughness by Dr. Samuel T. Darling, formerly Chief of the Laboratory of the Board of Health of the Panama Canal Zone, in his "Studies in Relation to Malaria."

Of interest in this connection is the following extract from the report on "Sanitation in Bengal for the Year 1914," published in Calcutta, 1915: "It is gratifying to observe that the efforts of the Malaria Committee to popularize quinine appear to be meeting with success, and there was considerable demand for quinine in the 'treatment' form in which it is now sold. The sale of quinine in this form has nearly doubled since August, 1913. Quinine was distributed free to school-children in the Hooghly district through the agency of the Education Department, and some District Boards spent considerable sums in the purchase of quinine for free distribution. . . . The first step towards the elimination of malaria is the extension of the use of quinine both as a prophylactic and as a curative medicine. Much good will no doubt result from measures for the improvement of drainage and cultivation, but these by themselves will not prevent the spread of malaria."*

K. Institutional Treatment of Malaria

On account of the fact that malaria is so largely a rural disease, it would seem of sufficient importance to undertake an inquiry into the rural hospital facilities for proper institutional treatment, as opposed to superficial and inadequate treatment at the patient's home. Since malaria is widely spread through carriers suffering from latent malaria, it is of the first importance that as far as practicable *every* malaria patient should be thoroughly cured of the disease, to the extent, at least, of no malarial parasites being ascertainable in the peripheral circulation. Since the guarding of malaria patients against reinfection is of sufficient importance as a public-health precaution, the institutional treatment of malaria suggests itself as decidedly more effective than treatment at the patient's home. Attention may be directed to the excellent sanitary results which have been obtained by means of adequate rural hospital facilities for plantation laborers in Hawaii and in connection with the plantations, etc., of the United Fruit Company, in Cuba, Guatemala, Costa Rica, Colombia, etc.†

*Some exceptionally useful observations on Quinine Propaganda in Bengal, by C. A. Bentley, and the Quininisation of School Children in the United Provinces, by Maj. F. D. Graham, are contained in the Proceedings of the Third Meeting of the General Malaria Committee held at Madras, in 1912. See, also, in this connection Chapter iv on the Treatment of Malarial Fevers, with special reference to the use of quinine in Malarial Fevers, by Chas. F. Craig, M. D., New York, 1909, and Chapter viii on Treatment of Malaria, in Deaderick and Thompson's "Endemic Diseases of the Southern States," Philadelphia, 1916.

†The excellent results of adequate hospital facilities are described by Malcolm Watson in his treatise on "Rural Sanitation in the Tropics," with special reference to the plantation system of the Dutch Tobacco Company, of the island of Sumatra. Between 1901 and 1911 the general hospital death rate was reduced from 11.4 per cent. to 2.6 per cent., and the general death rate of the entire labor force from 50.0 to 12.0 per 1,000. The principal hospital is located at Medan and contains about 600 beds. During 1910-1911 the admission rate for malaria was only 2.4 per cent.

A PLAN FOR ORGANIZED PREVENTION

L. Historical Research

The appearance and disappearance of malaria in different sections of the world during more or less prolonged periods of time have an important bearing upon the better understanding of the conditions and circumstances which govern the control and ultimate eradication of malarial disease in the western hemisphere. The early history of malaria in Greece and Italy and its relation to the social and economic progress of the populations concerned and its possible causative influence on the decay of certain nations of antiquity forcibly suggest the value of pertinent historical illustrations in support of modern efforts to eradicate malaria from vast portions of the western hemisphere which are at present either more or less uninhabitable on account of malarial disease or which have been materially hindered in their economic progress, as best illustrated by the Yazoo Delta of Mississippi, a large portion of the states of Arkansas and Louisiana and contiguous areas in the coastal plain of North and South Carolina and Georgia.*

M. Zoological

The practical use of natural enemies of mosquitoes suggests a vast field of qualified scientific research of a high order of importance. The cooperation of the United States Fish Commission might be enlisted in an effort to ascertain how far certain fishes have been found useful in the West Indies and Hawaii in local efforts at mosquito eradication, and whether such methods of eradication might advantageously be introduced into the United States. Much the same conclusion applies to a further inquiry into the efficiency and practical usefulness of alleged deterrent trees and plants, such as the eucalyptus, the papia, the chinaberry trees, water-plants, etc. The United States Department of Agriculture, through its numerous scientific subdivisions, in cooperation with the National Museum and the American Museum of Natural History, as well as other organized scientific bodies, should be in a position to render substantial aid in this direction. †

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*The most useful source of information on the early history of malarial diseases is the "Handbook of Geographical and Historical Pathology," by Dr. August Hirsch, translated by Charles Creighton, London, 1893.

Interesting historical data and early statistics are included in the treatise on Malaria by Prof. Dr. Angelo Celli, 2d German Ed., Berlin, 1913. A curious and practically unknown contribution to the early history of malaria is a work entitled "Dello Stato Fisico del Suolo de Roma. Memoria per servire d'illustrazione alla Carta Geognostica di questa citta. Di. G. Brocchi, Roma, 1820, reviewed in the *Edinburgh Review*, February, 1822. Also, "Travels of Intermittent Fever," in Rhode Island Annual Health Report, 1886.

†In an admirable address on "Insect Borne Diseases in Pan-America," by Dr. Juan Guiteras, Director of Health of Cuba, and professor of general pathology and tropical diseases in the University of Havana, read before the Second Pan-American Scientific Congress, an extended reference is made to the early observations of Dr. Josiah C. Nott, of Mobile, Ala., on yellow fever, as contrasted with bilious fever, and reasons for believing it a disease *sui generis*, its mode of propagation, remote cause, probable insect or animalcular origin, etc., which appeared in the *New Orleans Medical and Surgical Journal* for March, 1848. This paper for the first time presented the insect hypothesis in disease transmission, which has since become universally accepted on the basis of the subsequent precise ascertainment of the true cause of yellow fever by the United States Army Medical Board, consisting of Drs. Reed, Lazear, Carroll and Agramonte, who, however, in a large measure owe the results of their immortal discovery to the previous researches of Dr. Carlos J. Finlay, of Havana, who since 1881 had been investigating and reporting upon the possible relation of the mosquito to yellow fever, and of Dr. H. R. Carter, of the United States Public Health Service, who, some years earlier, had made public his epoch-making observations upon the intrinsic incubation of yellow fever. As well said by Major-General Gorgas, in his work on Sanitation in Panama, "The report of Carter turned out to be pure gold and was one of

The practical use of natural enemies of mosquitoes is discussed at some length in Volume I of the treatise on "The Mosquitoes of North and Central America and the West Indies," by Howard, Dyar and Knab, published by the Carnegie Institution in 1912. A reference of special interest is to the introduction of the so-called "millions," which are a minnow of very small size (the full-grown females measuring only about one and one-half inches in length, while the male is much smaller), from the island of Barbados, which is free from malaria, into the more or less permanent waters of the island of Antigua, which is considerably afflicted with the disease. It is said that many planters and others commented on the evident abatement of the mosquito nuisance in numerous localities. A limited test in the Panama Canal Zone was apparently productive of satisfactory results, for Major-General Gorgas is quoted in a statement to the effect that he approved of the use of "millions" wherever it could be done. Malcolm Watson, in his treatise on "Rural Sanitation in the Tropics," reporting upon conditions in Barbados, contradicts the general theory that the absence of malaria from the island was attributable to the universal presence of "millions," holding that Barbados is free from malaria "because of the relative absence of breeding-places," due to the exceedingly favorable conditions of natural subsoil drainage. In the treatise on "The Mosquitoes of North and Central America and the West Indies," by Howard, Dyar and Knab, extended consideration is also given to alleged deterrent trees and plants, chiefly the eucalyptus, ricinus and papaya, china-berry trees, peat and water-plants. The whole question of natural enemies is admirably summarized by Mr. John B. Smith, Entomologist of the New Jersey State Agricultural Experiment Station, in his report upon the mosquitoes occurring within that state, their habits, life history, etc.

XIV. General Conclusions and Observations on the Economic Importance of Malarial Diseases

The economic losses resulting from malaria are enormous, but exceedingly difficult of precise ascertainment. In 1903 Prof. Glen W. Herrick contributed an article to the *Popular Science Monthly* on The Relation of Malaria to Agricultural and Other Industries in the South, which in 1909 was followed by a bulletin of the Bureau of Entomology on The Economic Loss to the People of the United States Through Insects That Carry Disease, by L. O. Howard. The same distinguished authority gave more extended consideration to the subject in the first volume of the collective investigation on "The Mosquitoes of North and Central America and the West Indies," published by the Carnegie Institution in

the great steps in establishing the true method of transmission of yellow fever." The sanitary achievements in Havana, past and present, are primarily the work of Major-General W. C. Gorgas and Dr. Juan Guiteras. It is entirely due, however, to the enlightened attitude of the Cuban government that the theories of insect-borne diseases have been rigidly applied and that both yellow fever and malaria have become practically extinct in an island which, in former years, was often disastrously afflicted by both of these diseases. Reference may also be made here to an interesting contribution on the mosquitoes of the Republic of Cuba, by Dr. J. H. Pazos, of Havana.

1912. Prof. Howard at the time estimated the malaria death rate for the entire United States at 15 per 100,000 of population, equivalent to an annual loss of life of 12,000. He points out that this is but an inadequate indication of the economic loss in health and physical strength, for "A man may suffer from malaria throughout the greater part of his life and his productive capacity may be reduced from fifty to seventy-five per cent. and yet ultimately he may die from some entirely different immediate cause." Assuming, however, a mortality of 12,000 per annum, Prof. Howard estimates the number of cases of malaria at 1,500,000, of which it is safe to assume the larger proportion occur in adult life.

More recent discussions of the economic aspects of malaria, with special reference to agriculture, are by W. D. Hunter and D. L. Van Dine, of the United States Bureau of Entomology, concluding with a paper on the Relation of Malaria to Crop Production, by D. L. Van Dine, published in the *Scientific Monthly*, November, 1916. It is stated that Howard in 1909 estimated the annual economic loss on account of malaria throughout the United States at not less than $100,000,000, and subsequent investigations, including a careful analysis of actual plantation-labor experience, indicate that this estimate is probably conservative. William B. Hermes, in his treatise on malaria, with special reference to California, has estimated the economic loss on account of malaria in that state at nearly $3,000,000. The same authority quotes the opinion of the National Conservation Commission that eighty per cent. of the malaria in this country could be prevented. Dr. Graham A. Henson, in his work on malaria, published in 1913, observes with reference to the economic loss that on the basis of such data as were available and the knowledge "of what has been accomplished wherever a consistent campaign has been instituted against malaria infection it would appear that the time can not be far distant when the importance of the eradication of the disease will be taken up seriously by legislative and administrative bodies." This conclusion applies to every country in which malaria is known to prevail to a more or less serious degree; but to no section of the world as much as to the Southern States and the malarious regions of the Central and South American Republics. A material reduction in the malaria death rate can not fail to bring about a lesser prevalence of other serious diseases, for wherever malaria prevails extensively the general death rate is high, even though the disease itself may not be a predominant cause. The average death rate, for illustration, of Mauritius, which is intensely malarious, during the three years ending with 1906 was 37.6 per 1,000 of population, whereas the corresponding average rate for the nearby Seychelles Islands was only 15.9. The Seychelles are mountainous and practically free from anopheles mosquitoes.

The malaria death rate is not, of course, a sufficient basis for an estimate of the economic loss resulting largely in consequence of prolonged illness and diminished physical efficiency. The economic value of human life also varies considerably according to age, race and local labor

conditions, so much so that practically any and every estimate is largely a matter of pure conjecture. Estimating the present malaria mortality of the United States (for 1916) on the basis of revised data brought down to date for the Southern registration states and cities at 15,000 deaths and assuming a fatality rate of 1.5 per cent., the approximate number of cases of malaria in this country per annum can not fall below 1,000,000. Possibly the actual number is materially in excess of this assumption. The cause of malaria eradication, therefore, rests upon sound economic as well as self-evident humane considerations, leaving no escape from the final conclusion that the entire subject most urgently demands the qualified and intelligent coordination of all existing governmental agencies and related health-conserving activities, on the one hand, and a broad-minded public policy, on the other, with special reference, however, to expenditures in behalf of local antimalarial measures on the part of the general public. For economic reasons alone the effort would be worth while, since the economic results of effective antimalarial measures are a foregone conclusion. The attainment of more or less complete malaria eradication throughout the country will require many years of intelligent, coordinated effort, sustained by liberal governmental appropriations, than which no nation in the world could make a better investment for the good of its citizenship than the United States. The fundamental principle of permanent success in malaria eradication is the intelligent and effective coordination of all the measures and means, agencies and organizations, that can be utilized in the warfare against this most insidious foe of mankind.

A perfect working plan, however, can only be the result of extended experience and mature consideration on the part of many men and minds thoroughly familiar with the facts and conditions of local experience resulting either in failure or success. It is hoped, therefore, that the foregoing considerations and suggestions may prove of practical value in the ultimate attainment of our national ideal of the most perfect health and the longest attainable duration of life throughout the entire United States, which is far from being the case at the present time. As has well been said by the late William Edward Hartpole Lecky, "How different would have been the condition of the world, and how far greater would have been the popularity of strong monarchy if at the time when such a form of government generally prevailed rulers had had the intelligence to put before them the improvement of the health and the prolongation of the lives of their subjects as the main object of their policy rather than military glory or the acquisition of territory or mere ostentatious and selfish display!" This observation holds even more true for a republic, in which responsibility for governmental policy rests primarily upon the people themselves. In its final analysis, therefore, the problem of malaria eradication is one of public education and an aroused public conscience and understanding regarding the largely unnecessary loss of life and health in consequence of the continued and unnecessary

prevalence of malarial diseases. In proportion as the public knowledge of the measures and means whereby malaria can be eradicated is perfected will the elimination of this disease from, at least, the United States be attained within a measurable period of time.*

*Among the suggestive recent indications of an aroused interest in malaria eradication is a communication to the *Journal of Tropical Medicine and Hygiene*, by Dr. W. M. McDonald, Medical Officer of Health, St. John, Antigua, recommending the institution of rural anti-mosquito measures in the island (November 15, 1916). Dr. McDonald suggests the establishment of an experimental area for the practical ascertainment of the efficacy of various anti-mosquito measures on the basic principle of Government control, and to be regarded as bearing the same relation to the prevention of disease among laborers as the Agricultural Experimental Station does to the prevention of disease among canes. The principal objects of such an investigation are explained to be "(*a*) to provide practical knowledge of the working of various anti-mosquito measures; (*b*) to determine which of these measures in practice combine a maximum of efficiency with a minimum of cost; (*c*) to determine whether the cost of the more expensive measures is, in regard to financial limitations, warranted by the results of these measures; (*d*) to determine whether adoption of the least expensive measures is likely to prove of any avail even if we are deterred by financial limitations from carrying out the more expensive measures."

The several more important rural antimalarial measures are stated in their inverse order of importance, as follows: "(*a*) Utilization of the natural enemies of the mosquito, such as ducks, millions, and heavy winds. (*b*) Oiling of pools, ditches, and streams. (*c*) Drainage. (*d*) Grading and paving of such drains as cannot otherwise be effectually treated."

The article concludes with the statement that "the relative cost of efficiency of these measures can only be ascertained by practical experimental work in the field, but in view of the benefits which would result to the individual, to the landowners, to the Government, and to the community generally by the suppression or even the reduction of malarial and filarial disease in the colony, I would most respectfully represent that the public money could not be better spent than in the establishment of an experimental area for the carrying out of antimalarial measures having in view the eventual institution of an antimalarial campaign throughout the island. I venture to represent further that the present moment, when the interest of the managers and laborers has been attracted to the economic value of eradication of disease by the work done in the Ankylostomiasis Campaign, is an opportune time for enlisting the cooperation of the public in antimalarial work."

Of special practical educational value are the illustrated placards issued by the Philippine Health Service in the native languages, showing the life history of the mosquito and the method of transmission of malarial infection, used in the barrios of Mindoro.

Malaria in the Panama Canal Zone

Malaria Mortality by Periods

Rate per 10,000 Employees

1881–1890 French Construction	150.9
1905–1910 Early American	28.9
1911–1916 Recent American	4.0

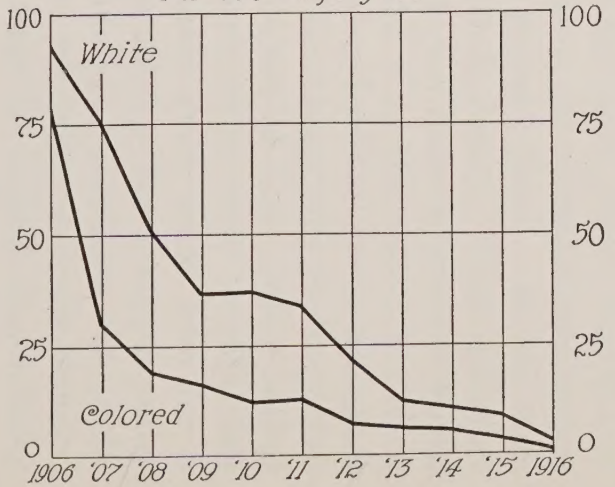
Case Fatality Rate Among Employees

Deaths per 1000 Cases

	White	Colored
1906–1910	4.7	10.2
1911–1915	5.4	3.8

Hospital Cases Among Employees 1906–1916

Per 100 Employees



Type of Malaria, 1907-1915

71,878 Hospital Cases Among Employees

Percent. of All Cases

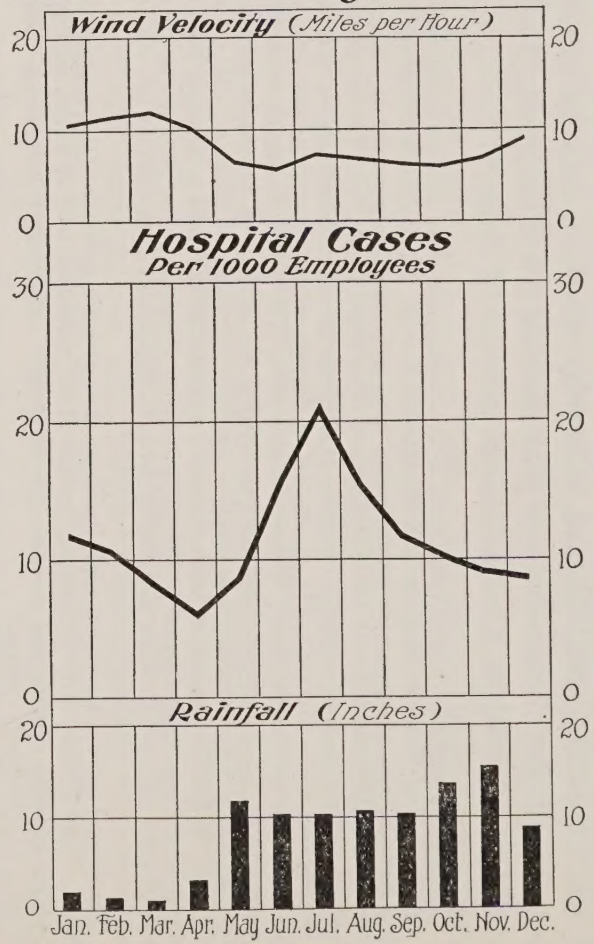
Estivo-Autumnal	46.4
Tertian	14.0
Mixed	0.8
Cachexia	0.6
Hemoglobinuric	0.5
Quartan	0.4
Undetermined, Clinical,	37.3
	100.0

Malaria Mortality, 1914-1915

Rate per 10,000 Population

City of Panama	11.5
City of Colon	5.3
Employees	2.0

Seasonal Variation in Malaria Morbidity, 1909-1913



PART III

SOME ESSENTIAL STATISTICAL CONSIDERATIONS

An effective and far-reaching practical plan of malaria eradication must obviously rest upon a well-considered statistical basis of evidence derived from trustworthy official and other sources. The selection of unit areas for active antimalarial measures is in its initial considerations largely a statistical problem, and the results of subsequent experience, or the efficiency or failure of particular methods and means, are often determinable by statistical methods alone. Many important aspects of the problem of malaria prophylaxis require the ascertainment of elementary conditions in conformity to qualified methods of statistical and even mathematical analysis. The best illustration of this point of view is the elaborate presentation of evidence on the prevention of malaria in the collective treatise on the subject by Sir Ronald Ross, which includes contributions by Prof. L. O. Howard, Major-General W. C. Gorgas, J. A. LePrince, Prof. A. Celli, etc. International statistics of malaria frequency are, unfortunately, not thoroughly trustworthy, although in a general way they may be relied upon as approximately conclusive. Since malaria is largely a disease of rural sections, it is really deplorable that the larger portion of the rural area of the Southern States in which the disease is known to prevail to a more or less serious degree should not be within the registration area as defined and accepted by the Division of Vital Statistics of the United States Census.

In view of the fact that the mortality from malaria is not a true index of the relative seriousness of malaria frequency *as a disease*, it is even more regrettable that malaria morbidity data for many important infected areas should not be obtainable otherwise than by means of institutional returns, which, of course, may or may not be conclusive. Since the fatality rate in malaria varies considerably according to the type or form of malarial infection, it is self-evident that the extent of morbidity is not always safely ascertainable, with even approximate accuracy, from mortality returns which fail to differentiate the principal types of malaria, particularly the tertian, the estivoautumnal and the quartan infection. In some sections one type prevails, to the practical exclusion of the others, with a high morbidity and a low mortality rate, while in others the morbidity rate may be less, but the mortality rate much higher. For the United States registration area during the period 1910-1914 the average mortality from malaria was 2.6 per 100,000 of population, which in proportion to the mortality from other causes is obviously insignificant. The returns for the United

States registration area, unfortunately, are exclusive of the sections of the Southern States where the disease is known to prevail to a more or less serious degree. Thus, for illustration, when the returns for the state of Kentucky and the registration cities of Tennessee and Alabama are combined, the resulting average malaria mortality rate is 15.0 per 100,000 of population. For the cities of Tennessee alone, however, the rate is 40.2. No general malaria mortality returns for states and large areas can, therefore, be considered conclusive, and in all cases a correction is necessary for the possible impairment of the data on account of the inclusion of institutional returns. *Malaria is nearly always a local problem*, and the rate of incidence is governed by local conditions. Even in the Pacific Coast States, where the disease is relatively rare and, as a general rule, not of serious importance, particular localities may be and are subject to a comparatively high rate of incidence of malarial infection, which is obscured in the low general average mortality or morbidity for the state at large. In North Carolina, including only municipalities with at least 1,000 population, the malaria mortality rate is 26 per 100,000 of population; in the city of Charleston, S. C., during the period 1910-1914, it was 30.9; in the principal cities of Georgia, 27.6; and in the principal cities of Florida, 27.7. These rates are fairly conclusive, but the populations directly concerned suffer to a much larger extent than is indicated by average returns.*

Probably the most intensely malarial sections of the United States are the Yazoo Delta counties of Mississippi, the river counties of Tennessee, the river counties of southeastern Missouri and the river counties of Arkansas and northern Louisiana. It is only, however, for the river counties of southeastern Missouri that approximately trustworthy data are available, and these indicate an extraordinary degree of malarial intensity. Combining the returns for seven counties of Missouri, it appears that the average rate of mortality from malaria for the four years ending with 1914 was 168.8 per 100,000 of population and that the rate was as high as 296.7 for Dunklin County, which as far as known is probably one of the most intensely malarial sections as regards the fatal form of malarial fever in this country. Possibly certain counties of Arkansas and Mississippi, however, are even more seriously affected, but no official mortality returns regarding them are at present available. It is quite probable that the local intensity may be decidedly higher, but thus far, excepting to the extent of the active efforts on

*Some exceptionally valuable local investigations have been made by the United States Public Health Service in the direction of ascertaining the precise degree of intensity in the geographical area. Among other publications of practical value reference may be made to reprint No. 160, Malarial Fevers in Arkansas; reprint No. 172, Malarial Fevers in South Carolina, Georgia and Florida; reprint No. 186, Malarial Fevers in Alabama; and reprint No. 193, Malarial Fevers in Mississippi. Reprint No. 277 has a general review of malaria morbidity by states and types of infection, with a due regard to race by counties and seasons of the year. This investigation, limited to eight Southern states, includes 81,085 cases of malaria reported, but only on the basis of 13 per cent. of returned replies to the cards mailed to practising physicians in the states referred to. The approximate morbidity rate, as estimated by this investigation, made chiefly under the direction of the late R. H. von Ezdorf, was 5.36 per 1,000. If calculated on the basis of complete returns, the true malaria morbidity rate in the eight states combined would be 4 per cent., equivalent to 600,000 affected persons for the year.

the part of the International Health Commission of the Rockefeller Foundation, a thoroughly qualified investigation has not been made. The practical importance of malaria frequency and the urgency of its eradication in southeastern Missouri are best illustrated by the fact that the rate for Dunklin County of 296.7 per 100,000 is in excess of the corresponding rate for Trinidad and Tobago of 218.9; and almost the same as the rate for Venezuela, which is 305.6. Even the city of Freetown, Sierra Leone, on the West Coast of Africa, with its notoriously high general death rate, has a malaria rate of only 251.8, in contrast to a rate of 296.7 for Dunklin County. Granting that the true intensity of malaria frequency can not be accurately determined by means of the death rate as ascertainable upon the basis of more or less untrustworthy death certificates from rural districts, it is, nevertheless, an entirely safe conclusion that there are still sections in the United States which are so seriously afflicted with malarial disease as to challenge comparison with some of the most unhealthy portions of other countries equally afflicted with malarial disease.*

Subject to the caution that all international malaria mortality statistics require to be accepted and used with extreme care, the available official data have been briefly summarized in Table I of the Appendix. According to this table the highest death rate from malaria at the present time (that is, the period ending generally with 1914 or 1915) prevails in the island of Mauritius, where during 1910-1914 it reached the extreme figure of 1176.9 per 100,000 of population. Among other conspicuous illustrations of an excessive incidence of malaria mention may be made of Nicaragua, where during 1908-1911 the mortality rate reached 727.5, British Honduras, where during 1914-1915 it reached 589.7, British Guiana, where during 1911-1915 it reached 421.0, the city of Guayaquil, Ecuador, where the rate is 424.0, and finally the Philippine Islands, where during the period 1909-1913, regardless of active efforts at eradication, the rate still maintained the high level of 397.5. The extraordinary significance of these figures may best be realized when it is stated that for Italy, which, in its southern portion at least, is generally considered intensely malarial, the mortality during 1909-1913 was only 10.0 per 100,000, and even among the European population of Algeria, which formerly was considered extremely unhealthful, in fact, the grave of Europeans settling in the interior or

*Mortality from Malaria in Seven Counties of Southern Missouri, 1911-1914

County	Total Population	Deaths from Malaria	Rate per 100,000 Population
Dunklin	130,766	388	296.7
Butler	86,716	155	178.7
Pemiscot	86,397	151	174.8
Stoddard	114,665	178	155.2
New Madrid	86,953	121	139.2
Scott	99,662	94	94.3
Mississippi	61,205	38	62.1
Seven Counties	666,364	1,125	168.8

engaged in colonization work, the malaria mortality was only 47.6 during the five years ending with 1912.*

It is realized, as said before, that these statistics are not conclusive. They have reference chiefly to large areas, regardless of the fact that malaria is almost invariably a strictly localized health problem. It has seemed best, therefore, for the purpose of a public discussion to draw particular attention to the malaria death rate of large cities, and, granting that the statistics are occasionally impaired by institutional admissions from the surrounding country, the data are in all probability, at least for general purposes, more useful and conclusive than the data for countries at large. The malaria mortality statistics of fourteen representative cities throughout the world have been brought together in Table II of the Appendix, for the purpose of emphasizing the wide range in malarial incidence in sections where the disease has been endemic for many years and the considerable actual and relative reduction in the malaria death rate in localities where the disease has been brought gradually, if not as yet entirely, under effective control.†

Among other astonishing illustrations of the truly remarkable progress achieved in consequence of the furtherance of antimalarial measures it is shown, by comparing the malaria death rate of Havana, Cuba, for 1900-1904, when it was 49.0 per 100,000 of population, with the corresponding death rate for 1910-1914, when it was 2.4 per 100,000, or practically negligible. The reduction achieved during the period under consideration was equivalent to 95.1 per cent. In St. Thomas, Danish West Indies, there has been a corresponding reduction in the mortality from malaria during the same period of 88.8 per cent., in Rio de Janeiro, Brazil, of 86.5 per cent., and in Colombo, Ceylon, of 84.9 per cent. These are, indeed, most gratifying and absolutely convincing evidences of a possible further reduction under efficient and continued antimalarial efforts, more or less in conformity to the principles of malaria eradication as set forth in the plan recommended to the National Committee on Malaria.

Since the results attained at Panama are the classical illustration of the truly marvelous possibilities of malaria control, it may be pointed out in this connection that, comparing the malaria death rate of Panama City during the period 1901-1905, when it reached the almost incredible figure of 973.5 per 100,000 of population, with the average mortality, of 159.9, of the city during the five years ending with 1915, there was an actual reduction in the malaria mortality of Panama City during the American administration, as compared with the former native or French

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*The morbidity from malaria in the jails of India has been reported upon for many years. Combining the returns for the several provinces, the admission rate from malaria per thousand of average daily strength has been reduced from 298.5 during 1894-1898 to 199.5 during 1904-1908 and 117.3 during 1914. The lowest rate on record was reported for the year 1912, when it was 105.0, followed by a rate of 108.2 during 1913.

†The general subject of village and town sanitation in relation to malaria and other diseases extended by the mosquito is described in some detail in "The Principles of Hygiene as Applied to Tropical and Sub-tropical Climates," by W. J. R. Simpson, London, 1908.

administration, of 813.6 per 100,000 of population, equivalent to 83.6 per cent. In Sao Paulo, Brazil, during the same period of time, the mortality from malaria was reduced 83.1 per cent. In Manila, Philippine Islands, it was reduced 79.1 per cent.; in Catania, Italy, 77.9 per cent.; and in New Orleans, La., 74.7 per cent. Where so much has been achieved within so relatively short a period of time, it is apparently a foregone conclusion that decidedly better results can be secured under still more advanced and well-considered methods of administration and control in the countries or cities where the disease at the present time continues to prevail to a more or less alarming degree. Thus, in Kingston, Jamaica, the malaria mortality has been reduced from 248.6 per 100,000 of population during 1901-1905 to 99.7 during 1911-1915, or 59.9 per cent.; but the present rate for Kingston of 99.7 is in marked contrast to the corresponding rate of 20.6 for Manila, of 8.8 for New Orleans and of only 2.4 for Havana. In the city of Memphis the average malaria mortality during 1900-1904 was 145.0 per 100,000; during 1910-1914 the rate was reduced to 74.2, or 48.8 per cent. Regardless of the gratifying decrease in the malaria mortality of selected cities, it is self-evident, in view of the low prevailing rates of 8.8 for New Orleans and 2.4 for Havana, that *the practical possibilities of complete malaria eradication are as yet far from having been attained.* The certainty, for illustration, that the malaria mortality of Memphis is materially increased by the negro population, more susceptible to malarial infection than the white race, merely emphasizes the national importance of malaria eradication, since, on the one hand, the negro element is of the greatest economic importance, and a measurable impairment of its physical efficiency must seriously react upon the aggregate productive energies of the nation considered as a whole; and, on the other hand, the negro, on account of extreme mobility and extensive migration, tends, perhaps more than any other factor, to spread the disease from infected to non-infected localities, as has well been illustrated in malaria outbreaks in northern communities where the anopheles mosquito is extremely common but ordinarily harmless, because of non-infection.

Recent malaria mortality statistics for thirty-four American cities are briefly summarized in Table IV of the Appendix. According to this table the average malaria mortality rate was reduced from 8.9 per 100,000 for the five years ending with 1904 to only 3.2 during the five years ending with 1914. There was, therefore, an actual reduction of 5.7 per 100,000 of population, equivalent to 64 per cent. The reduction was most marked in Key West, where the rate was reduced from 32.5 to only 2.0, or 93.8 per cent. Among other conspicuous achievements are the results secured in Wilmington, N. C., where the rate was reduced 81.9 per cent., and in Paducah, Ky., where the rate was reduced 57.2 per cent. The one suggestive exception to the rule of a general reduction throughout the country was Mobile, Ala., where the mortality

from malaria during the decade under review increased from 51.6 per 100,000 during the first five years to 60.4 during the last five years, or 17.1 per cent.*

The statistical evidence as regards the possibilities and future achievements of malaria eradication may, therefore, be considered absolutely conclusive. The statistical method, however, can be utilized, to much greater advantage than has heretofore been realized, in the scientific study of the geographical distribution of the disease and such elementary considerations as age, sex, race and occupation in their relation to climate, soil, topography, etc. In the United States the mortality from malaria falls chiefly upon the earlier ages, but the morbidity often seriously impairs social and economic efficiency in adult life.

Malaria also complicates many other diseases, even pregnancy and surgical operations. Malaria is, therefore, a much more important problem than is generally recognized by the public, more or less indifferent to its occurrence, upon the false assumption that chills and fevers have to be endured as a matter of course and in general are of no particular medical significance. The investigations which have been made by the Rockefeller Foundation and the United States Public Health Service and the conservative estimates as regards the economic loss arrived at by Prof. L. O. Howard and the equally important and suggestive observations on the mortality and cost of malaria by Sir Ronald Ross tend to emphasize the economic aspects of malaria eradication and the lamentable economic waste sustained by a given population or section in consequence of an excessive incidence of malarial disease.

The differential diagnosis of malaria is, however, exceedingly complex. Malaria complicates so many other important diseases that in infected sections it is rarely absent, at least in a latent form. Its relation to nephritis has been admirably described by William Sydney Thayer, in 1908. It is a well-known fact that the mortality from Bright's disease is much higher among the colored population of the Southern States than among the whites, a condition which in a measure must be ascribed to malarial infection.

The subject of blackwater fever lies outside the present discussion. Malarial hematuria, or hemoglobinuric fever, is of a much lesser degree of frequency occurrence in the Southern States at the present time than in former years. According to Craig, "Hemoglobinuric fever has no etiological connection with the malarial fevers," but he includes a brief discussion of the disease in his treatise on the malarial fevers, for the reason that "the disease most frequently occurs in malarious regions and very often in the subjects of malarial infection." He points out that, like kala-azar, "this disease has long been considered as due to malarial infection, but the more we inquire into its etiology, its

*During very recent years the malaria death rate of Mobile has decreased as follows: 1911, 77.8; 1912, 67.1; 1913, 53.1; and 48.6 during 1914.

distribution, symptomatology and pathology, the more must we become convinced that the malarial nature of the condition is far from certain, and that the evidence points to it being a separate disease entity, in all probability caused by a hitherto undiscovered organism." This conclusion, however, is strongly opposed by Drs. Deeks and James in their Report on Hemoglobinuric Fever in the Canal Zone, published in 1911. On the basis of 230 cases subjected to critical analysis, the authors conclude that "The amount of previous malaria, whether recent or remote, determines the prevalence of hemoglobinuric fever, and from these conclusions it is very evident that malaria is a predisposing factor of great importance in hemoglobinuric fever." The subject of blackwater fever in the tropical African dependencies of Great Britain is annually reported upon to Parliament in considerable detail, suggestive of corresponding special investigations in exceptionally infected localities in the United States. An exceedingly valuable scientific contribution to the subject of blackwater fever is a report by Capt. S. R. Christophers and Dr. C. A. Bentley, of the India medical service, published as "Scientific Memoir No. 35" of the Medical and Sanitary Departments of the Government of India, in 1909. The results of this investigation are summarized in the statement that if the conclusions as regards the malarial origin of blackwater fever are correct, "the prophylaxis of the condition is simply the prevention as far as possible of malarial infection, and the prompt and efficient treatment of this disease, with the view to prevent the occurrence of relapses." The point of view that excessive quininization is a cause of blackwater fever is not accepted, but, quite to the contrary, it is held that the systematic use of quinine is more or less effective for prophylactic purposes. A very useful general treatise on blackwater fever is by A. G. Newell, M. D., late special deputy health officer of the Bombay Municipality, etc., in which blackwater fever is defined as "bilious malignant tertian ague," and the prophylactic treatment advised is a well-considered method of quininization, combined with protection against mosquitoes to safeguard the patient against reinfection.

The ascertainment of the true rate of incidence of malaria in a given area is of the first importance, since there is entirely too much reliance upon general data, which are more or less misleading and inconclusive. Thus, for illustration, the malaria mortality rate of the United States registration area of 2.6 per 100,000 of population is absolutely inconclusive; whereas the excessive mortality from malaria in the southeastern river counties of Missouri of 168.8 is a true measure of the local importance of the malaria problem and the absolute urgency of effective methods of eradication and control. Even in that particular area, limited to only seven counties, the rate is as low as 62.1 in Mississippi County and as high as 296.7 in Dunklin County; in fact, in these very counties, the rate of local incidence will be found to vary widely by towns, or settlements or drainage districts, and comparatively nearby

sections may, on the one hand, be relatively free from the disease and, on the other, subject to an exceedingly high rate of frequency*

All local investigations or malaria surveys to be scientifically conclusive require to be made with reference to climatological and topographic considerations. In the Southern States the highest mortality from malaria prevails, as a rule, during the month of September, as regards both the white and the colored population, and the lowest rates of frequency prevail generally during the month of February, after proper correction is made for the variations in the length of the months. In Havana, however, the maximum mortality from malaria occurs in July, and the minimum in the month of February; whereas in the Panama Canal Zone the maximum rate prevails in July, and the minimum rate in April. †

The correlation of malaria to meteorological conditions has been attempted with a varying degree of success. There are reasons for believing that there is no specific correlation conforming to the principle of a general natural law, but that rather when such a correlation is found apparently to exist it is interdependent with local conditions. A minute analysis of the meteorological facts is, therefore, absolutely essential, if the conclusions arrived at shall square with the conception of scientific accuracy. In Manaos, Brazil, ‡ for illustration, a maximum malaria frequency coincides with a minimum rainfall, which is in marked contrast to the experience observed in other sections of the world. It is self-evident that mere rainfall as such can not be a direct causative factor, but that it is rather the opportunity provided for the breeding of the anopheles mosquito, which tends directly to increase the malaria death rate. When the rain falls in very large quantities during comparatively short periods of time, the very excess in rainfall may in itself be the means of destroying

*Of special interest in this connection are the Soil Surveys of Pemiscot County, published by the United States Bureau of Soils in 1912, of Stoddard County, published in 1914, and of Dunklin County, published in 1916. Also the Special Reports on the Little River Drainage District of Missouri, by Isham Randolph, Consulting Engineer, Chicago, Ill., and a Preliminary Report on the St. Francis Valley Drainage Project in Northeastern Arkansas, by Arthur E. Morgan, Office of Experiment Stations, Washington, D. C., 1909. For another excellent illustration of the practical value of thoroughgoing local malaria studies, reference may be made to the address on Malaria in Greece, by Sir Ronald Ross, published in the Smithsonian Report for 1908.

†See in this connection special publication No. 3, "The Mortality of the Western Hemisphere," published by The Prudential Insurance Company of America, on the occasion of the Panama-Pacific International Exposition, San Francisco, 1915.

‡RAINFALL AND MALARIA MORTALITY

Month	Manaos, Brazil, 1907-1914			Panama City, 1908-1914		
	Rainfall (inches)	Deaths from Malaria	Percentage Distribution*	Rainfall (inches)	Deaths from Malaria	Percentage Distribution*
January	8.4	253	6.3	0.9	80	9.6
February	7.8	293	8.0	0.9	63	8.3
March	10.0	328	8.2	0.4	49	5.8
April	8.5	303	7.8	3.1	41	5.1
May	7.0	345	8.6	9.1	53	6.3
June	3.4	398	10.3	6.8	71	8.8
July	1.3	479	11.9	7.2	84	10.0
August	1.1	472	11.8	8.3	80	9.6
September	1.7	365	9.4	7.1	67	8.3
October	4.0	276	6.9	10.0	78	9.4
November	5.2	205	5.3	9.1	66	8.1
December	8.6	220	5.5	6.5	90	10.7
Total	67.0	3,937	100.0	69.4	822	100.0

*Adjusted for varying length of months.

breeding-places of anopheles mosquitoes; and the subsequently rapid drying of the soil and the rapid evaporation of the standing water may aid in reducing malaria frequency. As a general rule, however, a heavy average rainfall, fairly normally distributed throughout the year, coincides with an excess in malaria frequency, provided the temperature conditions, humidity and wind force are all favorable.*

The malaria death rate is also materially modified by race and the migration of people from non-malarial countries to more or less intensely malarial regions. There can be no question of doubt but that some form of natural immunity or protection against malaria is acquired, if not otherwise than through the almost universal malarial infection in infancy in countries subject to an extremely high malaria rate. † Race is, therefore, of serious importance, as is best illustrated by the data for the southern part of the United States registration area, for which the returns are approximately trustworthy and according to which the average malaria death rate was 8.0 per 100,000 for the white population, against 29.0 for the colored. The contrast is much less marked in Cuba, where white males, for illustration, have a malaria death rate of 22.2, against a malaria death rate for the colored of 31.8, and where the white female malaria death rate is 16.5, and the colored 27.8. It has been found by experience in the West Indies, particularly in Jamaica and British Guiana, that the coolie immigrants from the East Indies are exceedingly liable to malaria, so much so that during 1905-1914, for illustration, the East Indian population of British Guiana experienced a malaria death rate of 547.6 per 100,000 of population. Since this element is imported solely for plantation purposes the impairment in labor efficiency resulting from malaria must reach extraordinary proportions, which, unfortunately, are imperfectly realized or indifferently regarded by the governments and the plantation element responsible for malaria eradication and health protection otherwise in the countries referred to. As a general statement it may be asserted that most of the hospital population in the island of Jamaica, on account of malaria, consists of East Indians, although this element constitutes but a relatively small proportion of the plantation labor of the island. In contrast, the remarkable achievement in health promotion and sanitation in Hawaii is the result of active and energetic administrative measures in coordination with the efforts of the sugar-planters of the island, which have reduced the death rate from all causes and from such diseases as most commonly prevail among the immigrant class to normal and even subnormal proportions.

These very general statistical considerations are merely intended to emphasize the urgency and practical usefulness of a thorough and

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*The annual variations of malaria with special reference to rainfall have been reported upon in some detail in the First Report on Malaria in Bengal, by Maj. A. B. Fry, M. D., Calcutta, 1912.

†See A Plea for a National Committee on the Eradication of Malaria, *New Orleans Medical and Surgical Journal*, August, 1916, for useful additional statistical information.

qualified analysis of the mortality and morbidity from malaria throughout that portion of the world in which the disease is known to exist to a more or less serious degree.* The practical importance of malaria eradication is so perfectly obvious that it should not require an extended argument in support of the plea and the plan of the National Committee on Malaria in the furtherance of the implied obligation, governmental or otherwise, contained in the resolution adopted by the Second Pan-American Scientific Congress. It is not going too far to say that *malaria eradication is essentially a labor problem of the first importance;* that an enormous amount of labor inefficiency due to malaria continues to hinder the progress of semi-tropical and tropical countries, which, if brought under control and completely done away with, must needs assist profoundly in the reclamation of the tropical regions for the practical needs of the world at large.† What has been done in this direction by the United Fruit Company in the gradual eradication of malaria from its plantations and from among its white employees from the United States, required for administrative purposes, is deserving of special consideration as perhaps the best illustration, next to the classical results secured in Panama, of the practical achievements and future possibilities of malaria eradication in the western world.‡ Even under present conditions, regardless of the progress which has been made in Banes, Cuba, 49 per cent. of the cases treated in the hospitals of that company are on account of malaria, in Guatamala the proportion was 42 per cent., and in Tela, Honduras, 39 per cent. (1915). Malaria has *not* been completely eradicated from the Isthmus of Panama, nor is it likely that for a long time the disease will be entirely eradicated from any section of the world; but its complete eradication is an ideal which need not disturb those who are working for the attainment of a material modification of and improvement in existing conditions. There is malaria in practically every state in the Union and in practically every country of the world. Wherever anopheles mosquitoes exist, there possibilities of malarial outbreaks exist also, provided, of course, climatological conditions are favorable. The best practical illustration of this conception of malaria eradication and control as a world problem is to be found in the experience which has resulted from the European War, and which, particularly in the case of

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*It is an error to assume that malaria prevails throughout the tropics, as pointed out in a note of the *Journal of the American Medical Association* under date of April 25, 1914. "According to the report by Maj. Brooke, of the United States Army, Cebu in the Philippines is free from malaria, although the anopheline mosquito has been found there, and it is surrounded by the zones in which malaria is epidemic. Brooke refers to the suggestion by Manson 'that there are some places free from malaria yet surrounded by epidemic zones, as in the case of Cebu, because in that particular area food conditions for the mosquito can exist which are inimical to the growth of parasites in their bodies.'" (See, also, "The Tropics," by C. R. Enock, New York, 1915.)

†The relation of malaria to agriculture has been made the subject of a special investigation by the Bureau of Entomology, published by the United States Department of Agriculture. In Madison Parish, La., it was found that twelve families cultivating 286 acres of land lost an aggregate of 88 weeks' time during the crop-growing season on account of malaria, or more than seven weeks per family. The financial loss was estimated as $24 per family.

‡For a full account of the sanitary achievements of the United Fruit Company, see "Conquest of the Tropics," by Frederick Upham Adams (New York, 1914), and the annual reports of the company's medical department for the years 1909-1915.

France and the Mediterranean countries, has resulted in serious complications as regards the medical treatment of the wounded and the physical efficiency of the forces. With commendable foresight, therefore, the British War Office has issued an admirable handbook on "Some Medical Diseases in the Mediterranean War Area," in which malaria is given the most extended consideration of all the diseases considered in detail. More important, therefore, than cerebrospinal fever, typhus fever, paratyphus, relapsing fever, heat-stroke or dysentery is malaria in the southern war area, and, as well said in the work referred to, "A considerable number of cases of malaria, *that most Protean of all diseases*, has occurred at Cape Hellas and Suvla Bay." Malaria is not likely to be of deciding importance in the present European War, but it may under given conditions prove as serious a factor as regards local conflicts as the disease unquestionably constitutes in the progress or decay of given localities or states.

The importance of malaria as a factor in military efficiency has been recognized by all authorities on military hygiene. The early United States Army experience, particularly in the Southern States, proves conclusively the extensive and serious prevalence of intermittent and remittent fevers and its relation to the resulting inefficiency or incapacity of the troops. As early as 1808, Edward Cutbush, M. D., of the United States Navy, in his observations on the means of preserving the health of the soldiers and sailors, states that "We learn from experience that fevers are little known in rough, hilly countries, where water flows with a rapid course; while we likewise know, that they are common in low and champaign countries, where water stagnates, or has only a sluggish motion: independent of which, those situations, which are in the neighborhood of swamps or near oozy banks of large rivers, have always been observed to be particularly liable to such diseases." Even more suggestive are the "Medical Sketches of the Campaigns of 1812-1814," by James Mann, M. D., published in Dedham, 1816. These sketches include observations on the extensive and serious prevalence of intermittent and remittent fevers in Burlington, Vt., and on the Niagara frontier. Attention is directed to the importance of drainage and cultivation in their relation to fever occurrence, the statement being, in part, that "In proportion as cultivation of the earth is extended by opening the forests and draining the lands, so will climate be improved, and its endemic diseases disappear. The heavy fogs of lakes and large rivers, which are impeded and suspended over their borders by woodlands until a late hour of the day, abstract from the body its vital heat, and subject the inhabitants to intermittent fevers, and other autumnal diseases, as dysentery and diarrhea. They, however, are less frequent at those points, on the lake shores, where cultivation has made some progress, and have disappeared where the lands are extensively improved. These autumnal diseases, which are now considered endemic in new settlements on the frontiers, will vanish as the forests are subdued, and

the marshes and swamps drained; while the husbandman will be remunerated by a twofold reward, higher degrees of health as well as accumulation of wealth."

These observations by a military surgeon of extensive experience are fully sustained by the results of a thorough statistical analysis of the sickness and mortality in the United States for the period 1819-1839, by Thomas Lawson, M. D., Surgeon-General, published in 1840. These early statistical investigations suggest an equally extended analysis of our more recent army experience, with special reference to the different army posts and fields of military occupation in tropical territory. The statistics of fever morbidity and mortality during the Civil War form an important contribution to medical history and experience, and even at the present time the observations on Malarial Influence on Army Life and Efficiency by Brigadier-General William A. Hammond, Surgeon-General, United States Army, published in 1863, are of value, regardless of the fact that they rest upon fundamentally erroneous assumptions as to the nature of malarial disease and its then unknown transmission from insects to man.

The truly enormous progress which has been made in malaria eradication and control during the long intervening period of years is reflected in the timely observations on the subject by Edward L. Munson, M. D., late Chief Medical Department, United States Army, in his treatise on "The Theory and Practice of Military Hygiene," published in 1901. The observations of Dr. Munson, which, it requires to be considered, precede the practical application of the discovery by Sir Ronald Ross of the insect transmission of malaria, are briefly summarized, with special reference to army experience, as follows:

Malaria has ravaged armies in every age and climate, and has frequently modified military operations or brought about their failure. Rome was saved from capture by malarial fevers, which so scourged the besieging Gauls under Brennus as to cause their retreat. In the year 208, the Roman army in Scotland lost 50,000 men out of a total of 80,000 from this cause. No military disaster caused by malarial infection was more complete, however, than that of the British expedition to the island of Walcheren, in 1809. On this occasion it has been said that the British were conquered before the battle. Out of an effective force of 39,219 there succumbed to the fever, between August 28th and December, no less than 23,175 men, while after the return to England there were 11,503 additional cases. But 217 men, during this disastrous expedition, were killed by the enemy. In the Seminole War, in Florida, our troops suffered severely from malarial infections. In the French army before Sebastopol there were 20,623 cases, with 2,179 deaths. In the Union forces, during the Civil War, there were 1,314,744 cases of malaria, with 10,062 deaths, giving a mortality of 3.92 per thousand strength. "But though the mortality from these fevers was comparatively light, their influence in detracting from the efficiency of the army was very great"—as well as largely influencing the rates of discharge for disability on account of resulting anemia and chronic malarial poisoning. The so-called "Chickahominy fever" was particularly severe in its effects. Malarial fevers prevailed in the French army during the Italian War and the occupation of the Papal States. Ashmead states that 5,995 Japanese soldiers, sent to Formosa in 1873, furnished 6,105 admissions to hospital, for continued malarial fevers, in a single year. In the French expedition in Madagascar, in 1895, out of a force of 22,850 men—combatants and carriers—there were 7,498 deaths

from disease; a mortality of about 33 per cent. Nearly all the deaths were from malarial fevers. During this expedition only 7 men were killed by the enemy and but 94 wounded. In the same year, a Spanish expedition in the Philippine Islands was scourged by malarial fever. During the last insurrection in Cuba, the Spanish forces were largely depleted by malarial infections of a severe type; the admissions to hospital for this cause, during the year 1897, amounting to 420 per thousand strength. In 1898, after the capture of Santiago, one-half of our forces in Cuba were incapacitated for duty at the same time by reason of malarial fevers. This grave condition of affairs evoked an appeal to the War Department, signed by all the officers of higher rank, for an immediate removal of these troops to a more healthy locality—using the sentence: "This army must be moved or perish."

Dr. Munson directed attention to the fact that since the Civil War the admissions for malaria for the entire army had been reduced from a maximum of 793.8 per 1,000 strength in 1868 to 78.9 per 1,000 in 1897. In consequence of the Spanish American War, of 1898, the admission rate on account of the exposure to malarial infection in the tropics was increased to 694.6 per 1,000. More recent statistics for the United States Army and Navy are briefly summarized in the two tables following:

MORBIDITY FROM MALARIA, UNITED STATES ARMY, 1901-1915

Rate per 1,000 Mean Strength

1901.....380.4	1906.....122.4	1911.....39.6
1902.....272.3	1907..... 88.7	1912.....51.7
1903.....201.2	1908..... 59.6	1913.....33.8
1904.....102.3	1909..... 49.4	1914.....29.4
1905.....122.3	1910..... 42.2	1915.....25.2

MORBIDITY FROM MALARIA, UNITED STATES NAVY, 1901-1915

Rate per 1,000 Mean Strength

1901.....41.4	1906.....43.6	1911.....12.1
1902.....45.1	1907.....31.4	1912.....11.6
1903.....32.8	1908.....21.8	1913.....12.1
1904.....39.1	1909.....18.3	1914.....17.4
1905.....24.8	1910.....11.8	1915.....17.7

These statistics reflect the direct influence of governmental policy based upon the modern knowledge of the insect transmission of malarial infections. The increase in the navy malaria morbidity rate during the last two years is accounted for by the naval operations in Mexico and the West Indies. The army malaria death rate has been reduced from 1.35 per 1,000 in 1900 to only 0.02 in 1915. In the navy the mortality from malaria since 1901 has been negligible.

The physical efficiency of an army is measured or determined by the constantly non-effective rate, that is, the proportion of men constantly on the sick list. The non-effective rate of the United States Army has been very materially reduced during recent years, but the ideal of 30 per 1,000 has not been attained. During 1909, for illustration, the non-effective rate was 42, which according to Havard was equivalent to a loss of 14.5 days from sickness or injury for each soldier, in contrast to an average loss of only 9.7 days for the navy and of 10.4 days for the British army. The practical significance of malaria as a basic consideration in problems of military efficiency and national preparedness therefore assumes the importance of a medical, economic and military problem of the first order.

Table I
Mortality from Malaria Throughout the World

WESTERN HEMISPHERE

Country	Period	Aggregate Population	Deaths from Malaria	Rate per 100,000 Population
Nicaragua	1908–1911	2,180,000	15,859	727.5
British Honduras	1914–1915	83,268	491	589.7
City of Guayaquil, Ecuador	1911–1915	420,000	1,781	424.0
British Guiana	1911–1915	1,516,710	6,385	421.0
City of San Salvador	1910–1914	324,900	1,223	376.4
Venezuela	1908–1912	13,525,191	41,331	305.6
Trinidad and Tobago	1910–1914	1,715,102	3,754	218.9
City of Paramaribo, D. Guiana	1908–1912	174,775	257	147.0
Panama Canal Zone	1911–1915	677,792	949	140.0
Sixteen Cities of Brazil	1909–1913	11,725,980	12,878	109.8
Brit. Leew'd and Windw'd Isls.	1910–1914	1,026,879	997	97.1
Porto Rico	1911–1915	4,675,044	3,793	81.1
Costa Rica	1911–1915	1,999,545	1,251	62.6
Jamaica	1911–1915	4,317,064	2,278	52.8*
St. Thomas, Danish W. I.	1911–1915	53,050	15	28.3
Cuba	1910–1914	11,561,416	2,535	21.9
United States Reg. Area	1910–1914	302,835,133	7,859	2.6

EASTERN HEMISPHERE

Mauritius	1910–1914	1,842,561	21,686	1176.9
Straits Settlements	1910–1914	3,596,554	19,818	551.0†
Zanzibar City	1910–1914	176,320	867	491.7
Philippine Islands	1909–1913	29,472,283	117,139	397.5
City of Freetown, Sierra Leone	1910–1914	170,000	428	251.8
Hongkong	1911–1915	1,999,524	1,667	83.4
Ceylon	1910–1914	20,817,228	11,304	54.3
Algiers (Europeans)	1908–1912	3,712,365	1,768	47.6
Spain	1906–1910	96,717,000	10,930	11.3
Italy	1909–1913	173,356,885	17,399	10.0
Portugal	1905–1909	28,817,465	1,874	6.5
Union of S. Africa (Europeans)	1912–1914	4,018,253	141	3.5
France	1908–1912	197,198,000	2,029	1.0
Commonwealth of Australia	1909–1913	22,583,681	174	0.8

Table II
A Decade of Malaria Mortality Reduction in Large Foreign Cities

City	Country	Period	Death Rate from Malaria per 100,000 Population	Period	Death Rate from Malaria per 100,000 Population	Reduction Per Cent.
Habana	Cuba	1900–1904	49.0	1910–1914	2.4	95.1
St. Thomas Is.,	Dan. W. I.	1900–1904	334.8	1910–1914	37.6	88.8
Rio de Janeiro	Brazil	1900–1904	152.9	1910–1914	20.7	86.5
Colombo	Ceylon	1900–1904	244.4	1910–1914	37.0	84.9
Panama City	Panama	1901–1905	973.5	1911–1915	159.9	83.6
Sao Paulo	Brazil	1899–1903	34.3	1909–1913	5.8	83.1
Manila	Philippine Is.	1902–1905	98.4	1912–1915	20.6	79.1
Catania	Italy	1899–1903	23.5	1909–1913	5.2	77.9
Kingston	Jamaica	1901–1905	248.6	1911–1915	99.7	59.9
Calcutta	India	1900–1904	676.5	1910–1914	291.8	56.9
Rome	Italy	1899–1903	16.6	1909–1913	8.9	46.4
Port of Spain	Trinidad	1900–1904	116.3	1910–1914	63.9	45.1
Hongkong	China (Br.)	1901–1905	126.5	1911–1915	83.4	34.1
Bahia	Brazil	1899–1903	157.6	1909–1913	123.7	21.5

*During these years were recorded in Jamaica as due to "fevers" without distinction 15,658 deaths, giving a rate of 362.7 per 100,000 of population.

†There were, also, in the Straits Settlements during this period 23,219 deaths from undefined fevers, giving a rate of 645.6 per 100,000 of population.

Table III
Mortality from Malaria in Italy—1894-1913

Period	Aggregate Population	Deaths from Malaria	Rate per 100,000 Pop.
1894–1898	157,530,358	69,108	43.9
1899–1903	162,555,072	58,659	36.1
1904–1908	166,876,011	28,888	17.3
1909–1913	173,587,368	17,399	10.0

Table IV
A Decade of Malaria Reduction in Thirty-four Cities of the United States

City	1900-1904 Aggregate Population	1900-1904 Total Deaths	1900-1904 Rate per 100,000 Population	1910-1914 Aggregate Population	1910-1914 Total Deaths	1910-1914 Rate per 100,000 Population	Percentage of Decrease
Key West, Fla	92,336	30	32.5	102,317	2	2.0	93.8
Richmond, Va	439,580	89	20.2	656,759	12	1.8	91.1
Boston, Mass	2,873,433	29	1.0	3,530,050	5	0.1	90.0
Providence, R. I	924,058	63	6.8	1,176,584	8	0.7	89.7
Newark, N. J	1,298,300	51	3.9	1,851,221	7	0.4	89.7
New York City, N.Y.	18,312,405	682	3.7	25,343,167	124	0.5	86.5
Washington, D. C	1,448,810	162	11.2	1,713,879	32	1.9	83.0
Jersey City, N. J	1,084,695	38	3.5	1,408,879	8	0.6	82.9
Toledo, Ohio	697,791	35	5.0	883,489	8	0.9	82.0
Wilmington, N. C	109,910	245	222.9	134,073	54	40.3	81.9
Bridgeport, Conn	387,740	23	5.9	544,995	6	1.1	81.4
Baltimore, Md	2,597,020	172	6.6	2,847,798	36	1.3	80.3
Jacksonville, Fla	155,886	266	170.6	323,646	110	34.0	80.1
San Antonio, Texas	312,270	178	57.0	531,476	69	13.0	77.1
New Orleans, La	1,490,336	518	34.8	1,753,479	154	8.8	74.7
New Haven, Conn	567,115	56	9.9	696,624	18	2.6	73.7
Chicago, Ill	9,006,276	96	1.1	11,481,145	39	0.3	72.7
Kansas City, Mo	897,475	60	6.7	1,329,298	28	2.1	68.7
Indianapolis, Ind	928,845	51	5.5	1,235,255	22	1.8	67.3
Nashville, Tenn	415,175	128	30.8	563,397	68	12.1	60.7
Alexandria, Va	73,480	12	16.3	77,538	5	6.4	60.7
St. Louis, Mo	2,372,644	275	11.6	3,560,135	162	4.6	60.3
Paducah, Ky	100,715	178	176.7	117,498	89	75.7	57.2
Philadelphia, Pa	6,737,795	76	1.1	8,030,511	40	0.5	54.5
Charleston, S. C	282,220	176	62.4	297,544	92	30.9	50.5
San Francisco, Calif.	1,792,101	50	2.8	2,167,443	31	1.4	50.0
Memphis, Tenn	528,245	766	145.0	685,525	509	74.2	48.8
Atlanta, Ga	496,051	51	10.3	836,074	46	5.5	46.6
Savannah, Ga	296,243	392	132.3	332,093	261	78.6	40.6
Evansville, Ind	305,723	40	13.1	352,075	28	8.0	38.9
St. Joseph, Mo	336,855	19	5.6	400,679	17	4.2	25.0
Norfolk, Va	294,486	85	28.9	404,396	92	22.7	21.5
Louisville, Ky	1,045,310	53	5.1	1,149,419	47	4.1	19.6
Mobile, Ala	195,560	101	51.6	268,100	162	60.4	+17.1*
Thirty-four cities	58,896,884	5,246	8.9	76,786,561	2,491	3.2	64.0

*Increase.

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